# DOCUMENT RESUME

ED 088 183 EA 005 916

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| TITLE | Report of Ad Hoc Committee on Energy Efficiency in Large Buildings to the Interdepartmental Fuel and Energy Committee of the State of New York. |
| INSTITUTION | New York State Interdepartmental Fuel and Energy Committee, Albany. |
| PUB DATE | 7 Mar 73 |
| NOTE | 213p.; Related documents are EA 005 917-918 |
| EDRS PRICE | MF-$0.75 HC-$10.20 |
| DESCRIPTORS | Air Conditioning Equipment; *Architectural Programing; *Building Design; Building Materials; Building Operation; Buildings; Controlled Environment; Cost Effectiveness; *Energy Conservation; *Facility Guidelines; *Fuel Consumption; Heating; Lighting Design; Maintenance; Standards; Ventilation |
| IDENTIFIERS | Heat Recovery Systems; New York State |

ABSTRACT

Unwarranted amounts of energy are wasted each year in providing major public and privately owned buildings and the desired environment within them. Improved design, construction, and maintenance and operation can save significant amounts of energy without impairment of these processes throughout the life cycle of these buildings, arbitrarily established as 50 years. To successfully attain this energy conservation, increased cooperation and coordination among owners, designers, contractors, maintenance and operation personnel, labor, and governmental agencies will be necessary. Implementing all of the recommendations contained in this report during the life cycle of a large building should result in a reduction in energy consumption of more than 50 percent. Therefore, there is great potential for energy conservation in large buildings, with the accompanying significant benefit of dollar savings. This report consists of a broad summary and overview of the energy conservation aspects of large buildings, followed by three subcommittee reports containing detailed studies and guideline recommendations in the three areas of design, construction, and maintenance and operation. A bibliography is provided. (Author)

ED 088183

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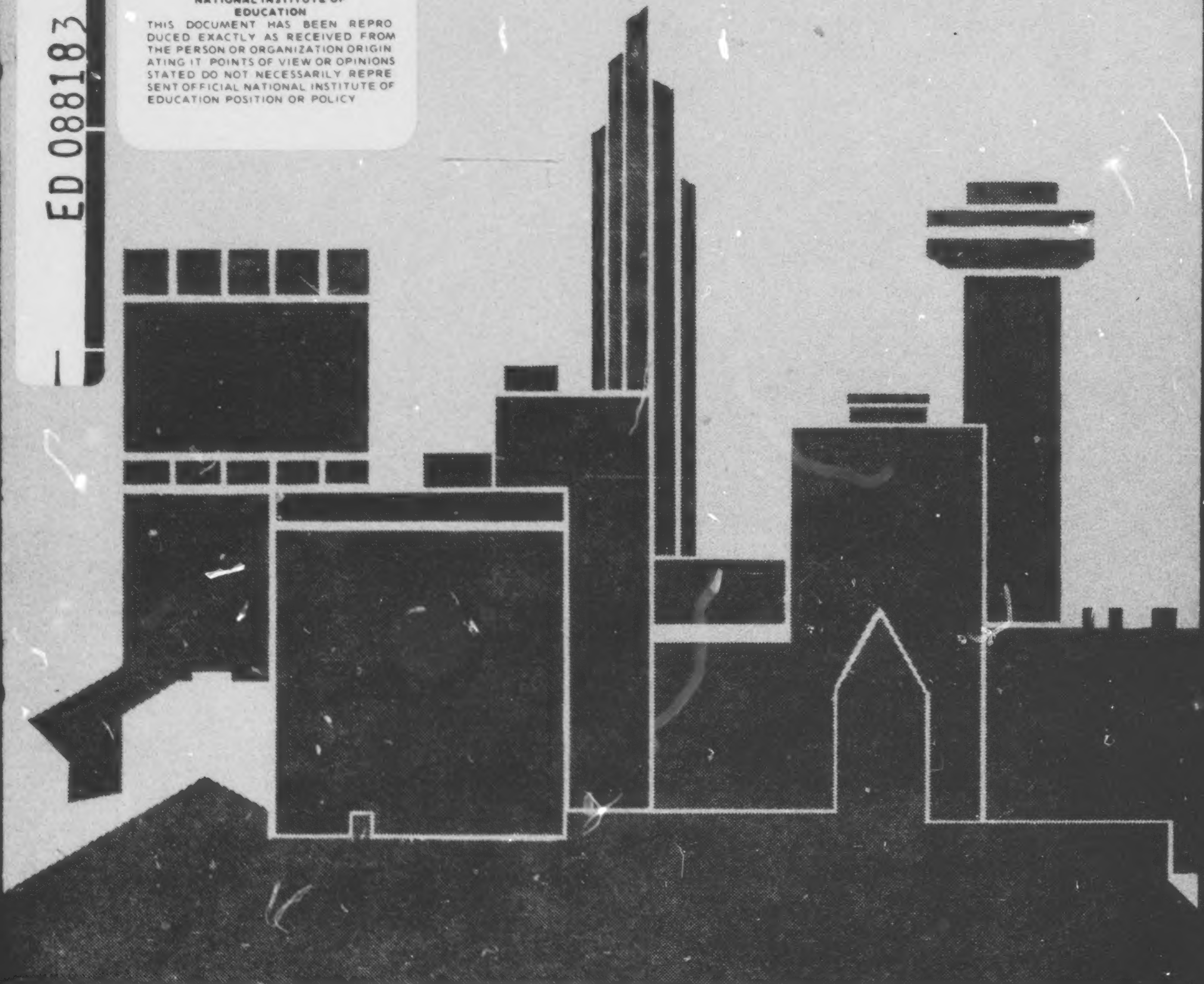

EA 005 916

# REPORT
# OF
# AD HOC COMMITTEE ON ENERGY EFFICIENCY IN LARGE BUILDINGS
# TO THE
# INTERDEPARTMENTAL FUEL AND ENERGY COMMITTEE
# OF THE
# STATE OF NEW YORK

March 7, 1973

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## I. INTRODUCTION

### A. BASIS FOR REPORT

In mid-July 1972, the Interdepartmental Fuel and Energy Committee, appointed earlier in the year by Governor Nelson A. Rockefeller, announced a three-pronged Action Plan to promote energy conservation. In his letter of July 28, 1972, Mr. Joseph C. Swidler, Chairman, Public Service Commission, State of New York, and Chairman, Interdepartmental Fuel and Energy Committee, requested that General A. C. O'Hara, Commissioner of the Office of General Services, State of New York, and Member of the above Committee, assume the lead for the Ad Hoc Committee for Energy Efficiency in Large Buildings. The Interdepartmental Fuel and Energy Committee Action Plan for Energy Conservation and Efficiency in Large Buildings, Appliances, and Transportation dated August 9, 1972, delineates the tasks of this Ad Hoc Committee and requires submission of the Committee's Report within six months after its first meeting. The first meeting of the Ad Hoc Committee was held on September 7, 1972. This Report addresses life cycle energy conservation and efficiency in large buildings throughout the entire processes of design, construction, and maintenance and operation for both public and private new and existing buildings.

## B. AD HOC COMMITTEE MEMBERSHIP

General O'Hara appointed the Ad Hoc Committee members as shown in Appendix D. The membership is composed of well-qualified professional architects, engineers, maintenance and operation specialists, contractors, labor representatives, and large building owners and managers. Both the governmental and private sectors are represented, as well as professional societies and organizations.

## C. SIGNIFICANCE

The United States with 6 percent of the world's population uses 35 percent of the world's energy. Total energy consumed in the United States in 1970 was equivalent to 80 persons working for each of us to maintain our modern way of life. In the past 100 years, overall demand for energy in the United States has increased twentyfold and the rate of increase is accelerating sharply.[1]

Commercial buildings alone account for about 15 percent of the total United States energy consumption.[2] Although energy consumption data in the other two building categories included in this Report (institutional buildings and large multi-dwelling residential complexes) is not available, it is readily apparent that these three areas constitute a substantial portion of the total United States energy consumption. Therefore, if significant energy conservation and efficiency can be attained in large buildings, this will make a very favorable contribution to lower critical energy requirements.

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[1] Kenneth F. Weaver, "The Search for Tomorrow's Power," National Geographic, November, 1972, p. 654.

[2] Eric Hirst and Robert Herendeen, "A Diet Guide for Chronic Energy Consumers," Science Review, October 28, 1972, p. 66.

## D. OBJECTIVES OF THE REPORT

The objectives of this Report are as follows:

1. Determine the energy effectiveness and efficiency of the design, construction, and maintenance and operation processes for providing and operating large new and existing buildings.

2. Identify changes in the above processes which would improve the efficiency and conservation of energy in large buildings.

3. Define the optimum roles of the building owner, designer, the constructor, and the operator in energy conservation in large buildings.

4. Draft guidelines for energy efficient design, construction, and maintenance and operation of new, rehabilitated, and existing large buildings.

## E. SCOPE OF REPORT

1. This Report consists of the review and analysis of the overall energy requirements for large buildings and how this energy use is influenced by the design, construction, and maintenance and operation functions involved. This is followed

by guideline recommendations for improved energy efficiency and conservation.

2. The Committee focused on the study of large commercial type buildings, institutional buildings, and large multi-dwelling residential complexes.

3. A great number of excellent studies, presentations, articles and papers and comments on them were analyzed to identify lessons learned and potential design, construction, and maintenance and operation changes for obtaining greater energy conservation in the future. These studies were used as departure points, and additional technical information was collected from other sources, including personal interviews and discussions.

4. Due to limited resources of time, personnel and funds, it was possible for the Committee to make only a limited number of in-depth studies. It was not feasible to conduct any research, development, test and evaluation programs. The Committee necessarily based its guideline recommendations on search of available literature and the extensive professional experience and expertise of Committee members. The Committee identified many areas where extensive studies and investigations must be made in the future. This will require a commitment of personnel and funds in substantial quantities over a considerable period of time. These study requirements are detailed in the body and recommendations of the Report.

5. Industrial processing plants and off-site utility generating plants were not considered by the Ad Hoc Committee due

to resource restraints; however, they are users of great quantities of energy with considerable potential for energy savings, and therefore should be the subject of future studies.

6. While the Ad Hoc Committee recognizes that the subject is not strictly within the purview of large building energy conservation, it feels that a detailed study of the present utility rate structure should be made since as presently constituted it appears to promote the inefficient use of energy by the large consumer.

## F. ORGANIZATION OF REPORT

1. This Report is composed of a broad summary and overview of the energy conservation aspects of large buildings. These are followed by the three Subcommittee Reports containing detailed studies and guideline recommendations in the three areas of design, construction, and maintenance and operation.

2. Recommendations are organized into three categories:

   a. Short Range - to be accomplished within the next two years.

   b. Middle Range - to be accomplished within two to five years from the present.

   c. Long Range - to be accomplished after five years from the present.

3. Recommendations are written to preclude substantial changes to the current standard of living and environmental comfort of the general population, and without creating an impediment to the orderly growth of business within New York State. It is

recognized that energy demands will continue to grow and that these progressive demands must be considered. However, they must be controlled within the capabilities of current and anticipated energy sources.

## II. ABSTRACT

Unwarranted amounts of energy are wasted each year in providing major public and privately owned buildings and the desired environment within them. Improved design, construction, and maintenance and operation can save significant amounts of energy without impairment of these processes, throughout the life cycle of these buildings, arbitrarily established as 50 years.

To successfully attain the above energy conservation, increased cooperation and coordination among owners, designers, contractors, maintenance and operation personnel, labor, and governmental agencies will be necessary.

By implementing all of the recommendations contained in this Report during the life cycle of a large building, the result will be a reduction in energy consumption of more than 50 percent. Therefore, there is great potential for energy conservation in large buildings, with the accompanying significant benefit of dollar savings.

# III. ENERGY CONSERVATION OVERVIEW

## A. BACKGROUND

1. Present owners, designers, constructors and operators of large buildings face even greater energy conservation problems than those which have historically plagued them in the past. This is caused by greatly increased overall costs and current and anticipated energy shortages.

2. Energy conservation in large buildings must start with the owners and designers. The designers must take into consideration not only design, but also both construction and maintenance and operation requirements, in order to achieve maximum possible energy conservation. However, the overall responsibility must be shared by the three disciplines involved. If contractors and maintenance and operation personnel do not provide feedback to designers, then optimum energy utilization cannot ultimately be accomplished.

3. Constructors of large buildings should share their expertise with both the designers and the maintenance and operation personnel. The contractors must become aware of possible energy conservation methods in the construction phase.

4. The maintenance and operation personnel will be living with the building over its entire life cycle. It is imperative that they have input to both the design and construction phases. For example, the maintenance personnel must service equipment and therefore must have sufficient space available in order to maintain equipment properly. Operators also have a responsibility to insure that equipment can be operated in a reasonable manner, consistent with manpower requirements.

5. All three areas of interest, designer, constructor, and operator must be willing to accept a give-and-take attitude to achieve the best overall long-run energy conservation within budgetary constraints. The Architectural/Engineering Project Design Review Board is one prime technique, especially at the schematic and preliminary design phases of a new building or major rehabilitation of an existing building, to utilize this input from all three disciplines' expertise affecting each others fields. One such project review board is explained in Annex A3.

6. The study of energy conservation and efficiency in large buildings is a very complex subject. The following list represents the major considerations involved in this Report; it provides an appreciation of the order of magnitude of effort required to develop the optimum programs for energy conservation in large buildings.

a. Design Phase Considerations:

- Energy Saving through Building Configuration and General Design Features
- Design of Fossil Fuel Heating Systems for Energy Efficiency
- Energy Efficiency in Electric Space Heating
- Design of Cooling Systems for Energy Efficiency
- Design of Ventilating Systems for Energy Efficiency
- Lighting Energy Conservation in Large Buildings
- Effect of Insulation on Energy Utilization
- Reduction of Heat Losses and Heat Gains at Building Entrances and Lobbies
- Effect of Building Material Selection on Energy Utilization
- Energy Efficiency through Heat Recovery
- Cost/Benefit Ratio Analysis in Energy Conservation

b. Construction Phase Considerations:

- Temporary Heat and Services
- Building Codes
- Joint Committees on Construction Problems
- Efficiency in Construction Management
- Instruction of Maintenance and Operation Personnel
- Labor Benefit Portability

c. Maintenance and Operation Phase Considerations

- Establish Minimum Levels of Environmental Comfort
- Establish Hours of Operation
- Reduce Electrical Peak Demands
- Power Factor Correction
- Shut-Down/Start-up Procedures
- Check and Improvement of Equipment Efficiencies
- Operating Techniques Utilizing Night Setback and Thermal Lag
- Installation or Utilization of Existing Economy Cycle Equipment
- Combustion and Heating System Efficiencies
- Lighting and Energy Conservation
- Water Conservation
- Tax Incentives
- Alterations to Existing Buildings and Demolition
- Preventive Maintenance Programs
- Establish Occupancy Standards

## B. POTENTIAL ENERGY CONSERVATION

Specific recommendations are stated in the three Subcommittee Reports in Appendices A, B, and C and will not be repeated in this section. The table shown below indicates the estimated potential percentage reduction of energy consumption in large buildings if all of the recommendations contained in this Report were implemented.

TABLE 1

CUMULATIVE ESTIMATED PERCENTAGE

REDUCTION IN ENERGY CONSUMPTION

| Recommendation Category | New Buildings | Rehabilitated Existing Buildings | Maintenance and Operation Functions |
|---|---|---|---|
| Short Range | 20 | 10 | 15 |
| Middle Range | 35 | 15 | 20 |
| Long Range | 50 | 20 | 25 |

NOTE: Percentages shown in above table cannot be added horizontally since these reductions apply only to each specific classification.

This table shows that anticipated total building life cycle energy savings for a new building which is designed, constructed, maintained and operated and rehabilitated, as required, in accordance with this Report's recommendations should result in a saving of more than 50 percent.

## C. GENERAL COMMENTS

Significant overall comments in regard to important implications of some of the Report recommendations are detailed below.

### 1. Complexity of Energy Requirements and Conservation

Energy requirements, including conservation, is a complex, many faceted problem which to solve will require a great magnitude of effort, including research, development, test, evaluation, studies in many disciplines and many millions of dollars to fund. An example of this complexity is cited in an article in Government Executive magazine for February 1973, in which the writer states, "Amid cries for a well-coordinated, goal oriented energy policy, 64 Federal agencies maintain some input to energy decisions."[1]

Another example of this complicated problem is detailed in a United States interagency report entitled The Potential for Energy Conservation.[2] This study points out that many measures it proposes require further investigation, legislation and review for economic impact. Significant changes in tax authorities and energy prices must be examined. Complex questions of feasibility and consumer acceptance are also brought up by the suggested measures.

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[1] John Wilpers, Associate Editor, "The Energy Crisis: Who's in Charge Here?," Government Executive, February, 1973.

[2] United States Government Interagency Staff Report, The Potential for Energy Conservation, Stock No. 4102-00009, Government Printing Office.

The means of carrying out conservation measures fall into three general categories: standards and regulation, tax incentives (credits and penalties) and educational campaigns.

The study pointed out that the use of standards and regulations offers precise control, but they may be difficult to compose and monitor. Their existence may also inhibit innovative solutions.

Tax incentives and penalties can provide financial inducements for energy conservation. The report added that educational campaigns are the least coercive of all programs and can help develop support for more stringent measures.

### 2. Centralized Coordination Required

The magnitude of the energy conservation problem requires centralized coordination of the effort at the national level under sponsorship of an agency such as the National Bureau of Standards, United States Department of Commerce, or by the proposed United States Department of National Resources, if established as recommended by President Nixon. This national body should provide overall direction and coordination of the energy conservation program with assistance from the 50 states, the professional and technical societies and associations and other interested groups such as industry, contractors, utilities, building owners and managers, labor representatives, etc. This centralization must be done to obtain the optimum results from the resources available for this important program. If the individual states and other organizations try to go it alone, there will be untold duplication, as is now being done, with little productive output attained. New York State should be in the lead in recommending that this national level program be instituted, with a request to be given specific assignments to study certain aspects of the energy conservation problem. The results of these studies would be fed back to the national coordinating body which would then disseminate them to all interested parties. This should be standard procedure for all organizations specifically interested in energy conservation.

### 3. Building Codes

An in-depth study should be instituted to analyze existing building codes to determine whether they need revision in order to conserve energy. This study should be organized on a national basis, using the staff and expertise of organizations such as the National Bureau of Standards. If a need for code revision is validated, then a standardized common code for the State of New York should be developed, based on minimum acceptable design and performance standards, through national consensus procedures, such as the American National Standards Institute. This code should be modified for the major cities of New York City, Buffalo, Rochester, Yonkers, and Albany which, due to great numbers of congested high-rise buildings, have special requirements for fire protection and safety.

### 4. Tax Incentives

To incorporate a number of the energy conservation recommendations of this Report into existing buildings will initially cost owners considerable sums of money; however, there will be an economic payoff in time due to decreased energy consumption. In many cases, these expenditures can be amortized in two to five years. Tax incentives should be utilized to economically persuade private building owners to make these initial investments. Precedent for tax reduction inducements in the best interests of the State exists in the New York State Department of Commerce's Job Incentive Program.

While it is realized that such tax incentives decrease the tax base from which governmental units are financed, this reduction would be comparatively small and for a relatively short period of time.

An alternative to tax incentives, would be to encourage the Federal and/or State Governments to enter into low interest rate loan programs for private businesses to cover additional energy conservation costs.

### 5. Environmental Cleanup and Energy Requirement Trade-Offs

Pollution reduction versus energy conservation must be studied and reasonable trade-offs developed. In his State-of-the-Union message to Congress on February 15, 1973, President Nixon said in part, "All development and use of energy sources carries environmental restrictions and we must find ways to minimize those restrictions while also providing adequate supplies of energy. I am fully confident that we can satisfy both of these imperatives." He warned: In protecting the environment, "We must strike a balance to permit expansion of energy supplies."

### 6. Educational and Communication Programs

One of the first steps to implement the short range recommendations of this Report is to initiate a State sponsored public communication program relating to the energy crisis and the need to conserve energy. This program should use the various media and include specific energy conserving instructions. Supplementing and following this communication program, a State sponsored educational program should be offered for owners, designers, constructors, operators and occupants of large buildings.

### 7. Legislative and Executive Orders

In order to implement some of the specific requirements contained in this Report, legislation or executive orders will be required. Also, some of the future studies will surely result in additional requirements for new or modified legislation.

As noted in the Action Plan of the Interdepartmental Fuel and Energy Committee, that Committee will be responsible for developing the required legislation and executive orders to implement guideline recommendations of this Report, as required.

### 8. Limited Resources of Ad Hoc Committee

Due to limited resources of time, personnel, and funds, it is regretted that the Ad Hoc Committee could not study in depth the extremely vital, complex problem of energy conservation. Years of effort and millions of dollars will be required to successfully investigate, study, analyze, and develop solutions to this vast problem. Technical, economical, environmental, legislative, and political implications of all aspects of energy consumption must be studied and resolved.

### 9. Future Studies on Energy Conservation

In future, continuing in-depth studies of energy conservation, adequate resources must be provided including sufficient qualified, professional personnel, available on a full-time basis, in addition to necessary staff and facility support, to satisfactorily accomplish such studies.

### 10. Guideline Recommendations Require Resources

Many of the recommendations made in this Report can be placed in effect now if necessary personnel and funds are made available to permit their being accomplished. It is pointed out that this program will be doubly beneficial in that recommendations, when implemented, will not only result in energy conservation, but ultimately in reduced expenditures of funds; however, it must be clearly noted that additional resources will be necessary, initially, to place these recommendations in effect. In other words funds will have to be spent in order to achieve subsequent energy conservation and save dollars. Such resources must be made available or the basic objective of producing the right design, the right construction, and the right maintenance and operation of large new and existing buildings to maximize energy conservation cannot be carried out.

## IV. SUMMARY OF MAJOR GUIDELINE RECOMMENDATIONS

### A. GENERAL OVERALL RECOMMENDATIONS

It is strongly recommended that due to the magnitude of the overall energy conservation program, that centralized coordination of this vast effort be established at the national level, such as the National Bureau of Standards or the proposed U. S. Department of Natural Resources at the earliest possible date. This complex program includes design criteria development, establishing uniform energy conservation standards and procedures for the design, construction, operation and maintenance of large buildings, and necessary legislation and regulatory body code changes as required. This national body should provide overall direction and coordination of the total energy conservation program, assisted by the 50 states, professional and technical societies and associations, and other interested groups such as industry, utilities, contractors, and building owners. Such centralization is required to obtain optimum results from resources available to accomplish this vitally important program. If individual states and other organizations proceed independently, there will be untold duplication, as is now being done, with comparatively little output attained.

The following three sections summarize the major guideline recommendations in Energy-Efficient Design, Construction, and Maintenance and Operation of Large Buildings, in the Short, Middle, and Long Ranges, respectively. For an in-depth description of the detailed study and recommendations, see Appendices A, B, and C.

## B. MAJOR GUIDELINE RECOMMENDATIONS FOR ENERGY-EFFICIENT DESIGN OF LARGE BUILDINGS

### 1. Short Range

The following guideline recommendations are for accomplishment within the next two years.

a. In buildings at start of planning stage, study site for natural assists to environment control problems, such as microclimate, winds, trees, exposures and adjacent structures.

b. In buildings already planned, but without construction documents, analyze each exposure separately for:

- Use of natural light.
- Heat gain by conduction in summer and winter.
- Heat gain and loss through radiation at glass areas.
- Impact on ventilation, heating and cooling through openable sections of outside wall.

c. Use most recent criteria in selecting outdoor design temperatures. Consider building heat storage capacity, occupied hours, daily temperature range, auxiliary sources of heat, etc.

d. Size heating equipment so that gross output does not exceed approximately 125 percent of the net heating load. When the net heating load exceeds 1,000,000 Btu per hour, use multiple boiler approach.

e. Design central heating systems to take advantage of internal heat loads and thermal lag. Use as many heating zones as economically feasible.

f. Additional design considerations: eliminate standing gas pilots, utilize heat recovery for systems with large makeup air requirements, use separate domestic hot water heating equipment for summer use, use systems to recover flue gas energy and study indoor temperature requirements in more detail when selecting design conditions.

g. Establish a professionally qualified independent investigating group at the national level, with no commitment, pro or con, to establish the effectiveness of energy use in electric heating.

h. Where electric heating is used, use the baseboard type with each unit containing its own thermostat. Electric reheat should not be used. Consider variable air volume or heat recovery systems in lieu of electric reheat. Electric heat pumps should be considered in the context of a complete system.

i. Design cooling systems for more efficient use of energy, as follows:

- Use outdoor design conditions based on conditions which are not exceeded more than 5 percent of the time.
- Avoid over-sizing of equipment.
- Consider use of heat-of-light systems where light levels exceed 75 footcandles.
- Avoid use of high pressure, high horsepower central fan systems.
- Use direct outside air supply to fume and exhaust hoods where possible. Provide hoods at equipment and exhaust non-recoverable heat and moisture directly to outdoors.

- Use area or spot cooling for special purpose areas.
- Study energy consumption of air-cooled versus water cooled condensers before selection of equipment. Design equipment on a modular basis. Specify packaged equipment on a Btuh/watt basis for greater efficiency.
- Provide proper controls to maintain flexibility of operation in large central systems.

j. Design ventilating systems for more efficient use of energy, as follows:

- Investigate ways to introduce ventilation air from outdoors directly into areas which require high ventilation.
- Zone ventilating systems so that spaces not requiring ventilation may be easily shut off.
- Utilize chemically activated deodorizers in toilet rooms and locker rooms to reduce the need for excessive ventilation.

k. Design lighting systems for more efficient use of energy as follows:

- Design lighting for expected activity.
- Design with more effective lighting fixtures, windows and skylights.
- Use efficient light sources (higher lumen/watt).
- Provide flexibility in the control of lighting.

l. Reduce heat loss and heat gain through building walls, roofs, windows, etc., by the following:

- Require storm windows or double glazed sash on new and existing buildings.
- Require that adequate insulation be provided in walls and roofs of new buildings and where practicable in existing buildings.

m. Design building entrances and lobbies for minimum heat losses and heat gains as follows:

- Install revolving doors or entrance vestibules to replace single bank doors in new and existing buildings which have infiltration problems at entrances.
- In new and existing buildings, seal the building envelope, particularly at upper floors, so as to obtain a tight building, if the building is designed as a sealed building.

n. Energy may be saved through heat recovery.

- Recognize that there is energy available within buildings which can be recovered and reused, thereby reducing primary energy requirements.
- Use heat recovery principles in designing heating, ventilating and air conditioning systems.
- Use heat pumps where feasible in buildings.

o. A cost/benefit ratio analysis will be of great benefit in energy conservation as follows:

- All state agencies involved in building construction should require a 50 year cost/benefit analysis study for each major project including an isolated study of energy use. Design fees should be increased to permit both the comparative studies and the cost/benefit analysis.
- All building programs assisted by State funding (housing, schools, medical facilities, etc.) should be required to comply in a similar manner.
- The private sector, particularly banks and insurance companies that provide mortgages for speculative building, should be encouraged to require cost/benefit analysis before granting loans.

p. Architectural/Engineering Project Design Review Boards should be utilized to provide technical/professional reviews of major new and rehabilitation projects at prime milestones of design and following completion of construction. These boards include owners, architects, engineers of each specialty, maintenance and operation personnel, construction supervisors and inspectors. The review insures that the project design results in an energy efficient facility from all possible angles.

2. Middle Range

The following guideline recommendations are for accomplishment within two to five years from the present.

a. State construction agencies should designate certain State projects as energy conservation projects.

b. The most significant changes to pursue in the design of ventilating systems would involve the various governmental and municipal agencies to jointly modify their existing codes and to reach agreement on ventilation standards as developed by the national energy conservation coordinating agency.

c. Illuminating Engineering Society (IES) should refine light level criteria to include maximum as well as minimum standards.

d. The design of heating, ventilating, and air conditioning systems should include control of interior static pressure throughout the structure.

3. Long Range

The following guideline recommendations are for accomplishment after five years from present.

a. Develop new, more versatile, higher performing building skins including:

- Flexible solar devices.
- Higher insulating capability.
- Reduced infiltration.
- Greater thermal retention.
- Selective insulation gain.
- Interchangeability to respond to different conditions.

It is recommended that the single national energy conservation agency undertake the development and coordination of this effort.

b. The State should utilize the results of any study approved by the national energy conservation agency on minimum "U" values for walls, roofs, floors and windows and require the use of these minimum "U" values in new construction through legislative or other action.

## C. MAJOR GUIDELINE RECOMMENDATIONS FOR ENERGY-EFFICIENT CONSTRUCTION OF LARGE BUILDINGS

### 1. Short Range

#### a. Temporary Heat and Services

- Utilize the Design and Construction Group of the New York State Office of General Services specifications for Temporary Heat during construction of new buildings as a model or standard in building construction contracts.
- Use the permanent heating, electric, water, and other systems, wherever possible during construction of new buildings in order to eliminate the provision of temporary services.

#### b. Efficiency in Construction Management

All designers should consult with contractors for their inputs, during both preliminary and final design phases, for information and recommendations on construction technology and economies, with especial emphasis on ways and means for conserving energy.

#### c. Instruction of Maintenance and Operation Personnel

Employees of the owner who will maintain and operate newly installed equipment should receive instruction in their maintenance and operation from qualified representatives of the prime contractor(s), his subcontractors, vendors, and manufacturers, with the requirement for such instruction to be set forth in the specifications.

## 2. Middle Range Recommendations

### a. Building Codes

An in-depth study should be instituted at the national level to analyze existing building codes to determine whether they need revision in order to conserve energy. If such a need is validated, then a standardized, common code for the State of New York should be developed, based on minimum acceptable performance standards, using national consensus procedures for establishing such standards. This code should except the major cities of New York City, Buffalo, Rochester, Yonkers, and Albany which have special high-rise requirements, due to great numbers of congested high-rise buildings, especially in the areas of fire protection and safety. Specifically tailored energy conservation requirements should be developed for these cities.

### b. Labor Benefit Portability

Sponsor or support legislation to assure portability of labor benefit programs. These would ultimately result in energy conservation by providing a better supply of skilled workmen.

## D. MAJOR GUIDELINE RECOMMENDATIONS FOR ENERGY-EFFICIENT MAINTENANCE AND OPERATION OF LARGE BUILDINGS

### 1. Short Range

#### a. Guidelines for all State and Non-State Buildings

- Initiate a public communication/education program relating to the energy crisis and the need to conserve energy.
- The following energy-efficient maintenance and operations features of large buildings should be recommended as guidelines for State, municipal and private buildings:
  - Reduce corridor, room and outdoor lighting to the maximum extent consistent with operational requirements, safety and security. The above-mentioned reductions in light level can be accomplished by turning off selected lights, substituting incandescent lamps of lower wattage, reducing total illumination per area to the minimum requirement of the Illuminating Engineering Society, and installation of additional localized switching. Control window brightness during daylight hours to redirect and utilize the available light.

- Shut down air conditioning equipment and reduce heating levels to the maximum extent possible on weekends and holidays in buildings unoccupied during those periods.
- Reduce heated and cooled air supply to unoccupied space such as storerooms and unoccupied areas. Establish minimum winter and maximum summer operating temperatures as a function of room use.
- Reduce amounts of outside ventilation air used in central heating, ventilation and air conditioning systems to meet the minimum ventilations requirements. Insure proper use of economy cycle where equipment is available.
- Give consideration, on days expected to be hot, to cooling the building below normal during the night and early morning hours and allowing the inside air temperature to rise during the afternoon. This action would reduce the cooling requirement and the amount of power consumed by air conditioning equipment during the peak load period.
- Keep filter systems clean to insure adequate circulation within the building and minimize fan horsepower.

    - Inspect and repair where necessary, the wall and ceiling insulation, caulking, weather stripping and storm windows of all buildings.
    - Verify that pipe insulation is provided on all steam or hot water lines passing through air conditioned spaces, and on all chilled water lines and ducts containing cold air which pass through non-air conditioned spaces.
    - Post instructions covering operation and maintenance procedures for occupants, building operators and building managers.

- Individual employees and tenants of large buildings of the State, municipalities and private sector should be encouraged to:
    - Turn off window air-conditioning units shortly before the end of the business day.
    - Report leaky water faucets, radiators, piping, valves, etc. immediately.
    - Draw or partially close blinds, shades, and draperies on the sunny side of the building.
    - Keep windows or outside doors closed during heating and cooling seasons.

- Utilize the minimum artificial lighting during daylight hours in rooms provided with adequate windows or skylight illumination.
- Keep other unnecessary lights turned off, such as those in storerooms, closets, or other spaces not being occupied.
- Shut off lights when leaving the office or other work areas.
- Turn off electric fans, coffee makers and other appliances when not required.

b. Regulatory Codes

Establish national regulatory codes to restrict or penalize the inefficient or wasteful energy consumer. A central national agency should be empowered to serve as coordinator and distributor of allocated funds for implementation of Federal code requirements. Note: The U. S. report on "Patterns of Energy Consumption in the United States" points out that many measures it proposes require further investigation, legislation and review for economic impact. Consequently, any implementation of any New York State Committee's recommendations on energy conservation should be closely coordinated with those of the Federal Government.

2. Middle Range

a. Mandatory Requirement for only State Buildings

Require each State facility to implement the recommendations on energy conservation of this section. This implementation shall include the planning of capital improvements and manpower necessary to realize these energy savings, plus any required executive orders. (The State should print and distribute copies of this report to each State facility.)

The proposed recommendations for each State facility are as follows:

- All items of previous section on short range recommendations which have not been implemented.
- Assign a top management official and staff personnel at each major State facility to monitor and supervise the energy conservation effort to insure that prescribed guidelines are being carried out.
- Publicize the use of strict conservation practices through announcements at staff meetings, notices posted on bulletin boards, and newsletters. Where reductions in equipment use are made in public buildings or facilities, post notices describing why this is necessary.
- Consider changing the working hours in areas where employees occupy air conditioned buildings, so that quitting time occurs prior to the period of peakload demand at which time air conditioning would be shut down. Consideration should also be given to shutting down of air conditioning equipment prior to quitting time.

### b. Distribution of this Report

Print and distribute copies of this report to the operators of all large non-state buildings and request voluntary implementation of its energy conservation guidelines.

### c. Prototype Implementation

On an existing large State building, implement the recommendations of this report as a prototype to quantify conservation of energy principles and any possible resulting reduced maintenance and operation costs.

d. Environmental Pollution vs Energy Crisis

Initiate a complete study to review and evaluate the existing environmental pollution codes versus the Energy/Fuel Crisis. Revise the criteria in New York State pollution codes, accordingly, to reflect the requirements of existing energy crisis, if allowable by U. S. Government standards. Bring this problem to duly authorized Federal authorities if changes required cannot be accomplished.

3. Long Range

a. Review and revise public utilities rate structures to encourage energy conservation.

b. Establish tax incentives aimed at energy conservation.

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# APPENDIX A

# REPORT
# ON
# ENERGY-EFFICIENT
# DESIGN
# OF
# LARGE BUILDINGS

Submitted by:

Subcommittee on Energy-Efficient
Design
of
Ad Hoc Committee on Energy Efficiency
in Large Buildings,
Interdepartmental Fuel and Energy
Committee of New York State

March 7, 1973

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## I. INTRODUCTION

Eventually, every energy expenditure of a building can be related back to decisions made in the design stage. During the construction of the building, the materials used, the amounts of materials employed to satisfy program requirements, the selection and design of structural systems, and the means used to incorporate the materials into their positions in the building all require varying amounts of energy.

After construction is completed and when the building is in use, its energy consumption per year will be determined to a great extent by the performance requirements built into it during the design stage - the amount of heating necessary to replace the heat lost through the walls, roof, openings and ventilation; the amount of energy expended by using the lighting system; the amount of cooling required to offset heat gained by solar radiation, heat from lights, people, and equipment heat exhaust; the amount of energy to carry on special building activities - e.g. merchandising, office equipment operation and advertising; the amount of energy required to operate the pumps and fans built into the structure; and the amount of energy required to operate the building as determined by the actual efficiency of the equipment and of the fuel source.

The maintenance and operation of the building is to some extent fixed at the design phase. A complex system that will not operate near its design level will represent an energy wastefulness. Where over-sensitive adjustments are necessary for efficient performance, absence of skilled and specially trained maintenance personnel can result in excess energy use. An over-simplified system, such as one with either too few controls of lighting or limited number of temperature zones will also require unnecessary energy consumption.

The designer's lack of knowledge about construction and maintenance and operation capabilities can result in the incorporation of building features that do not perform as anticipated, such as buildings with greater heat losses than the heating plant was designed to offset.

Since the design process predominately predetermines energy consumption, the committee members have looked into some of the energy uses in all of the above areas where significant reductions may be achieved by careful and coordinated design decisions. Where areas of possible savings have been identified, but were not possible of being researched due to resource limitations, these have been included as subjects for future study.

Because some recommendations could be put into effect immediately, others could be in the near future with minor administration or code changes, and others require longer range studies, development of new equipment or changes in technology or construction practices, we have catalogued our recommendations as short range - within the next couple of years, middle range - from two to five years hence; and long range - beyond five years.

The current nationwide search for the means to reduce energy demand and consumption has led to the simultaneous preparation of a number of independent studies with some overlapping. Where we have found such studies, we have extracted conclusions if they seemed applicable to this report. Undoubtedly, the months ahead will produce additional recommendations that might well be added to those listed. The divisions of the report have been determined more for editorial convenience than for the purpose of isolating the areas of saving by category. The interrelationships and trade-offs - the effect of one decision on another, the increased initial dollar costs necessary to achieve long range dollar (and energy) savings - are too complex, in general, to be dealt with in a satisfactory manner in this report, due to limited resources of time, personnel and dollars.

## II. SUMMARY

We have made some rough evaluations of possible energy savings. If all the recommendations contained in the short range category were incorporated in new building designs, an energy saving of approximately 20% might be expected. Alterations to existing buildings could reduce their energy consumption by about 10%.

If all the recommendations contained in the middle range category were incorporated in new building designs, an additional energy saving of 15% might be expected. Alterations to existing buildings might further reduce their energy consumption by 5%.

If all the recommendations contained in the long range category could be achieved and were incorporated in new building designs, a further energy saving of 15% might be expected. Alterations to existing buildings could reduce their energy consumption by an additional 5%. These total approximately 50% for new, and 20% for existing buildings.

## III. DETAILED STUDIES OF BUILDING DESIGN

Various specific areas affected by design decisions are separately discussed with specific recommendations in each area, as follows:

### A. ENERGY SAVING THROUGH BUILDING CONFIGURATION AND GENERAL DESIGN FEATURES.

1. **Discussion**:

a. The shape of a building, its orientation, the positioning in relation to prevailing winds, its depth to width ratio, the maximum distance from an interior point to an outside wall, and its floor area to height ratio all have an effect on the eventual energy consumption of the building, in addition to the immediate effect of the building materials that go into the construction.

b. The immediate effects of different wall and roof performance standards, lighting standards, natural ventilation, and mechanical provision for heating, cooling and ventilation are discussed elsewhere. The impact of building configuration and general design features on energy efficiency is the sole concern of this section.

c. There are conflicting requirements made on an exterior wall. Maximum glass area can reduce light requirements (if provision is made to reduce lighting when natural light is adequate) and can therefore, reduce the air conditioning to remove the heat of the unnecessary lighting. It also, depending on exposure and geographic location, introduces radiant heat from the sun, which when balanced with increased transmission loss through the glass, can reduce wintertime heating requirements. Summertime cooling requirements will be increased. Depending on whether the glazing is single, double or triple, it loses an ascertainable amount of heat in winter, usually more than a non-glazed wall would. Reduction of solar loads may be accomplished in the design of the buildings by selective placement and size of glass areas, particularly on south and west facades, by the use of shading devices that will keep out a significant portion of summer sun, by the use of reflective glass (preferable to heat absorbing glass which stores some of the heat in the glass and radiates it into the space), and by taking advantage of deciduous trees that will keep solar loads off parts of the building in summer. Density of construction will store day time heat and release it slowly at night. Green areas around a building will prevent the heating of masonry surfaces and the re-radiating of that heat into the building. If a building is sealed, it requires a mechanical system to deliver mandatory quantities of supply air for ventilation, heating and cooling. If it has operable sections, (windows or louvers) the requirements for mechanical introduction of fresh air may be reduced for perimeter zones, but results in the accidental introduction of outside air and the consequential loss of heated and/or cooled air to the outside.

d. There is also an important psychological component that is supplied by a view of the outside and even by the ability to open a window or other device and experience directly the temperature, noises and odors of the world outside the building. The internal programmatic requirements of the building can be markedly different in regard to the use or elimination of glass. For example, a patient's room in a hospital will want some visual connection with the outdoors, while a recording studio will want a massive material that will keep out unwanted sound.

e. In the past, in a period of necessarily low energy utilization, these various conflicting requirements were put into a set of workable compromises that allowed minimum interjections of energy to create tolerable, often very comfortable living and working conditions - light by candles, crystals and curved mirrors, heat provided by masonry stones and retained by heavy walls. In the optimization of energy use today, it is important to consider these principles, in addition to evaluating maximum mechanical performance inside a minimum surface area volume.

f. Design review boards have been used to review design documents of new construction. These boards include owners, architects, engineers of each specialty, maintenance and operation personnel, inspectors and contractors. The review ensures that the design results in energy efficient design of construction from all possible angles. Annex A3 is an example of such a review board.

g. The amount of building space required for the performance of certain tasks may be reduced through tighter programming and more efficient planning.

h. The State, through its direct building programs and its subsidization of other programs, directly or indirectly controls or influences billions of dollars worth of building construction, in schools, universities, hospitals, housing, community facilities, health facilities and transportation facilities. In addition, there are other sectors - commercial and industrial, for example - whose building construction is influenced or controlled by State agencies such as the New York State Urban Development Corporation.

State agencies directly involved in the building field include the Office of General Services, State University Construction Fund, Dormitory Authority, Health and Mental Hygiene Facilities Improvement Corporation, and others. If 5 percent of the buildings were found unnecessary, this would represent a significant saving. For every $80 million in building that is saved, a megawatt of generating capacity is freed for other purposes.

i. The feasibility of the development of computer programs to optimize energy savings through building design should be studied.[1]

2. Recommendations:

a. Short Range:

(1) In buildings already planned, but without construction documents, analyze each exposure separately for:

(a) Use of natural light to achieve:

-savings in electric utilization

-reduction in air-conditioning

(b) Heat gain by conduction in summer and winter, which results in:

-greater air-conditioning load

-lesser heating load

(c) Heat gain and loss through radiation at glass areas, which changes air-conditioning and heating loads.

(d) Impact on ventilation, heating and cooling through openable sections of outside wall, which result in:

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[1] John L. Kmetzo, of Syska and Hennessy Consulting Engineering Firm, AIA Journal, December, 1972, pp. 26-28.

-less mechanical ventilation requirements.

-greater infiltration

-less cooling at 55° to 75° outdoor temperatures.

-more noise (in some areas)

(2) In buildings at start of planning stage:

(a) Study site for natural assists to environmental control problems, such as:

-microclimate

-winds

-trees

-exposures

-adjacent structures

(b) Merge these determinants with those listed under a. (1), above.

b. Middle Range:

(1) If feasible, develop (or adapt) computer programs for design in all State buildings. Make this available to other planning groups of State agencies and the private sector, (consider grants for development of such studies).

(2) Investigate the possibility of the State establishing an umbrella organization with powers to deal with regulatory agencies as well as private industry in regard to energy conservation.

(3) Designate certain State projects as energy conservation research projects, as the General Services Administration

has done with a new office building project in Manchester, N.H., incorporating energy conservation designs.

c. Long Range:

(1) Development of new, more versatile, higher performing building skins including:

- flexible solar devices
- higher insulating capability
- reduced infiltration
- greater thermal retention
- selective insolation gain
- interchangeability to respond to different conditions.

It is recommended that a single national agency, such as Buildings Research Institute of the National Bureau of Standards undertake this effort. The State should participate in it, rather than duplicate it.

## B. DESIGN OF FOSSIL FUEL HEATING SYSTEMS FOR ENERGY EFFICIENCY

### 1. Discussion:

A reasonable sophistication in engineering design is necessary to allow a heating system to perform efficiently and thereby provide a plant that can provide acceptable conditions with a minimum use of energy.

#### a. General:

(1) Comfort Criteria

Determine the comfort criteria necessary in accordance with the latest ASHRAE Guide. This includes: Design indoor temperature in winter and summer; design temperatures in areas of special application such as computer rooms; and include the controls necessary to maintain this design temperature over varying external environmental conditions.

(2) Outdoor Design Temperatures

Since we have considerable data that indicates that the winter design temperatures for New York City will be higher than 16 degrees F. for 97 ½ percent of the winter, it does not make sense to arbitrarily select the temperatures of 0 degrees F. or 5 degrees F. as a winter outside design temperature. Therefore, use 16 degrees F. for masonry buildings in New York City. Similar considerations should be made for other locations.

#### b. Heating Load:

Determine the net heating load for the building, including an analysis of heat gains and losses in the building, the time at which these heat gains occur, the use of heat reclaiming devices, heating of outside air for variable ventilation requirements with occupancy, heat gain sources (such as solar, lighting, people and equipment), the types and complexity of the system sequencing and program of operation which will maintain the structure at the desired levels of comfort. Analyze the load profile on an hourly basis, since many of the heat gains in the building may not be available at the time the peak heat loss occurs. Do not use average values. Use the following criteria to determine the size of the heating equipment necessary to meet the load:

c. Sizing Heating Equipment

(1) The heating equipment should be sized so that the gross output does not exceed approximately 125% of the net heating load. If a boiler plant for a hi-rise building is very tightly designed, indications show that it might operate at maximum capacity for 50 to 60 percent of the entire winter. A boiler plant, however, that is over designed, (and many are over designed by 200 to 300 percent), will never operate at full capacity during any portion of the heating season, with consequent greater waste of energy.

(2) Guaranteed Efficiency Method

Large boiler installations are often bid competitively so that comparatively low efficiency installations are built. A method which New York State has used successfully for approximately ten years in bidding large boilers is the Guaranteed Efficiency Method. See Annex A-2. With this method the lowest responsible and reliable bidder is the bidder whose proposal is computed by the State as the lowest combined sum in dollars of the bid price and the fuel cost, and which will best promote the public interest. The fuel cost as estimated by the formula is added to the bid price. The sum of these is the basis which determines the lowest combined value. The lowest combined value will be a factor in determining the "lowest responsible and reliable bidder" as defined above. This method promotes energy conservation.

(3) Multiple Versus Single Heating Units:

When the net heating load is greater than 1,000,000 Btu per hour, consideration should be given to a multiple boiler approach, designed so that the gross output of the individual heating units involved will closely match the load profile of the structure at both high and low load conditions. Boilers should be controlled so each boiler goes from "lead" to "lag" position sequentially, either automatically or manually, per time period (daily, weekly or monthly). At least 90 percent of the modules should operate at 100 percent of their installed capacity. As long as oil fired or gas fired equipment operates at peak capacity, maximum combustion efficiencies can be maintained. Many utility companies have found that modular boilers are saving about 30 percent of the fuel that would be used in a boiler plant utilizing only one or two large fire tube boilers.

(4) General heating systems should be designed making maximum use of internal heat gains in order to save energy utilized.

c. Zoning:

It is extremely wasteful of energy to try to control the entire heating system of a high-rise building with only one or two zones. To realize good control over energy usage, use as many individual zones as required and economically feasible. In addition, design of the distribution system should use a similar design concept so that it will neither overheat nor overcool a particular section of the structure in order to maintain a comfortable level of internal temperature in another portion of the structure. Where this is difficult to achieve, consideration should be given to operating an isolated heating and cooling system for those portions of the structure which have unusual heating and cooling requirements. Examples of these are: computer rooms, dining rooms, kitchens, conference rooms, etc.

d. Maintenance & Operation Manual:

Composite, integrated maintenance and operation instructional manuals coordinating all trades and equipment of the structure for optimal system operation are a design responsibility. At the time the equipment is installed, clear, concise, indestructible printed instructions should be permanently mounted near each major item of equipment describing operation steps required for efficient performance and designating where operating personnel can have questions answered, or obtain emergency assistance. This should be done during the construction document phase of the project design, by a Maintenance Specialist through the architect/engineer as a contract requirement, with a fee adjustment to take care of this additional design requirement.

e. Additional Design and Development Considerations:

(1) It is estimated that gas pilots consume more than 223 billion cubic feet of natural gas per year in the more than 30 million gas-heated homes in the United States. Pilots on water heaters, gas dryers, refrigerators and other appliances waste additional gas. Electric ignition should be used in place of standing

gas pilots for gas burners.[1]

(2) For every project which requires more than 2,000 CFM of fresh air, consideration should be given to devices which will transfer energy from the building exhaust air to incoming fresh air.[2]

(3) It has been proven that less fuel is used in fired heating equipment operated near its rated capacity than in equipment operated at a low percentage of capacity. Accordingly, it is more economical in terms of fuel consumption to use separately fired domestic hot water generating equipment rather than to use a heating boiler at a small percent of its capacity in the summer.

(4) Institute the development of a low cost, simple control device that can be installed inexpensively on each piece of radiation and which will react rapidly to local environmental conditions. This would be an extension of current industry recommended practice to have local (individual area) zone controls. Local zone control is not yet provided in such building categories as New York City housing. The control device must be part of a system design which can react to load changes, and thus, decrease fuel usage proportionally.

(5) The heat pipe, which has no moving parts, is a relatively new development in efficient heat transfer. Hence, there should be excellent applications for this product, particularly in recovering waste heat from flue gases and other exhaust air. It must be kept in mind, however, that the flue gas temperature in a

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[1] Fred S. Dubin, "If You Want to Save Energy", AIA Journal, December, 1972.

[2] Ibid.

well designed system approaches the minimum necessary to prevent condensation and provide draft.

(6) Replace Outmoded Inefficient Heating System:

At the time of the heating plant replacement, a re-evaluation of the design heat loss and hot water requirements should be made. New equipment should closely match the re-evaluated criteria and not be sized to duplicate the old equipment, which may have been or have become mis-sized. Multiple heating plant design should be considered. Use design considerations from design of new building criteria.

2. Recommendations:

a. Short Range

(1) Use judgment in selecting outdoor design temperatures. For winter, consider building heat storage capacity, insulation, percent glass, occupied hours, daily temperature range, auxiliary sources of heat, etc. Massive institutional buildings with little glass should be designed from the current ASHRAE[3] tables for 97½% occurrence.

(2) Size heating equipment so that gross output does not exceed approximately 125% of the net heating load.

(3) When the net heating load exceeds 1,000,000 Btu per hour, use multiple boiler approach.

(4) Design central heating systems to take maximum advantage of internal heat loads and thermal lag.

(5) Use as many heating zones as economically

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[3] "Weather Data and Design Conditions", ASHRAE Handbook of Fundamentals, 1967.

feasible. Where possible, use individual unit controls.

(6) Design systems for efficient maintenance and operation.

(7) Additional Design Considerations:

Eliminate standing gas pilots, utilize heat recovery for systems with large makeup air requirements, use separate domestic hot water heating equipment for summer use, develop an effective system to recover flue gas energy and study indoor design temperature requirements in more detail when determining design conditions.

(8) Install local (individual area) controls in lieu of large zone using currently available local control devices on individual radiation.

b. Middle Range

Institute the development of a low cost, simple control device which can be installed inexpensively on each piece of radiation.

c. Long Range

None.

## C. ENERGY EFFICIENCY IN ELECTRIC SPACE HEATING

### 1. Discussion:

a. In New York State the major uses of electricity for space heating occur in high-rise multiple dwelling buildings, for reheat systems in office buildings, for unattended vacation houses, and for temporary heat on construction sites. If electric resistance heating is used, a very efficient type of electric heat-system from an energy conservation point of view, is baseboard electric resistance heating with each element containing its own thermostat. It reacts almost instantaneously to internal heat gains and outside influences such as solar radiation. Many fan coil and incremental air conditioning units utilize electric resistance heating elements. Also, central station type of air handling units have electric resistance heaters or hydronic coils with separate electric boilers. Electricity can also be used for heating through use of heat pumps. While conversion of primary energy to heat is higher through use of heat pumps, efficiency of utilization and control will be comparable to any other system with heat generated at a central point.

b. There are unresolved questions about the overall energy efficiency of electric heating, primarily based on the loss of efficiency in using fossil fuel to generate electricity which is further reduced by transformer and transmission losses. One point of view holds that with fossil fuel responsible for 95% of power generation, and with 100% efficiency at the resistance heating element, less than 30% of the original energy is recaptured at the point of use. With average boiler efficiencies and reasonable thermostat and time controls, directly used fossil fuel can deliver 60% to 75% of the potential energy as heat, thereby saving half the fuel required in electric heating. Those who favor electric heating cite the responsiveness of the controls and the efficiency of delivery as being able to more than offset that 70% built-in inefficiency of electric generation and transmission. Those who oppose electric heating also cite the increased energy use at other times due to the promotional rates for electricity in "all-electric" installations. Those who favor it, also describe its electric load balancing characteristics. Those who oppose it cite the higher insulation standards required for it, noting that similar insulation would also save fossil fuel, if used directly. Also, they note that diverting of oil to electric generators to satisfy rapidly increasing winter peaks can jeopardize the oil supply required for space heating installations solely dependent on it. More study is required in this area to determine the relative energy effectiveness of fossil fuel and electric heating.

c. This report does not attempt to resolve the question definitively. An energy study comparing primary fuel usage (that is, fuel necessary to generate the electricity used for heating versus fuel necessary to heat directly) should be made before selecting the energy source for heating for any particular project.

2. Recommendations:

a. Short Range:

(1) Establish a professionally qualified independent investigating group at the national level, with no commitment, pro or con, to establish the effectiveness of energy

use in electric heating.

(2) If electric heating is used, use the baseboard type with each piece of baseboard containing its own thermostat, resistant type electric heaters in fan-coil units or resistant type electric heaters in central type heating, ventilating and air conditioning air handling units, depending on type of heating, cooling and air conditioning.

(3) Electric reheat should not be utilized. Variable air volume or heat recovery systems should be considered in lieu of electric reheat.

(4) Electric heat pumps should be considered in the context of a complete system. (The efficiency of a heat pump is greater than the efficiency of straight electric resistance heating).

b. Middle Range:

(1) Evaluate results of the study on the effectiveness of energy use in electric heating and publicize any valid recommendations.

c. Long Range:

None.

## D. DESIGN OF COOLING SYSTEMS FOR ENERGY EFFICIENCY

### 1. Discussion:

a. Since cooling systems are responsible for the most critical peak of electric usage, any energy savings in this area have the effect not only of saving non-renewable primary fuel with its attendant reduction in pollution, but also reduces the urgency for increasing generation capacity and transmission lines.

b. The usual practice is to design heating and cooling systems based on the outdoor conditions which are not exceeded more than 2½% of the time. Systems can be designed for the 5% condition, except for facilities for the elderly, industrial process or health care areas. The few hours a year when spaces are warmer or cooler (less than 30 hours a year) than our present "standards" seem a small price to pay for a more energy efficient system.[1]

c. Computers should be used in calculating heating and cooling loads on an hourly basis, for sizing ducts, piping and equipment. If equipment is over-sized due to excessive manual or improper computer load calculations, there will be excessive first costs and inefficiency, especially at part-load conditions. Computers should be utilized to determine the optimum orientation of the building and the relative energy usage of alternative systems and construction materials. Safety factors should be used with a great deal of judgment. Heat storage in the building should be considered.

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[1] Fred S. Dubin, "Energy Conservation Through Building Design and A Wiser Use of Electricity".

d. Use energy conservation and heat recovery systems. Select more efficient equipment. There are many energy conservation systems which are equally effective, regardless of the source of energy. Since all-electric H.V.A.C. systems consume more primary energy fuel for a given task than on-site fossil fuel systems, the potential savings in energy by using energy conservation and heat recovery is much greater when used with electrical systems.

e. Wherever illumination footcandle levels exceeds 75, consideration should be given to "heat-of-light" systems. All air "heat-of-light" systems reduce the amount of sensible heat entering the space and reduce the amount of air which must circulate in the air conditioning system, thereby reducing fan horse-power and energy consumption. The wet "troffer" type "heat-of-light" system saves even a greater amount of energy as well as some capital costs of the air conditioning system, since it results in a smaller refrigeration plant, as well as smaller air handling units and ducts. Both systems reduce the quantity of sheet metal in the ducts.[2]

f. Large high pressure, high horse-power, central fan systems should also be avoided where possible. In place of large central fan systems, chilled and hot water can be pumped to decentralized, smaller, low-pressure air handling units, each to serve a specific area in the building. Space must be provided for the air handling units, but the piping systems occupy less space than large duct systems; in some cases, the elimination of the large duct system permits lower ceiling heights and considerable savings in building volume - hence less energy consumption for the same useable building area.[3]

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[2] Ibid

g. Examine the building program to eliminate unnecessary exhaust hoods. Exhaust hoods are often operated continuously without performing a continuous function - functions which could be divided into a smaller number of hoods. There are hoods available in which outdoor air may be introduced directly, thus avoiding the necessity of heating and cooling large amounts of make-up air.

h. Large sensible and latent heat gains may be reduced by providing hoods at equipment and exhausting excess heat and moisture from the hoods directly to the outside instead of installing cooling capacity to handle these loads.

i. Spot cooling may be used, especially in buildings with small occupancy at specialized tasks, without air conditioning the entire space. Many laundries have evaporative spot cooling installations.

j. Air-cooled refrigeration systems use more energy than water cooled systems. For each project, a study should be made to determine energy consumption of air-cooled versus water-cooled condensing system.

k. Over-sized heating and cooling equipment use excessive energy at part loads. Equipment should be selected on a modular basis, so that smaller pieces of equipment, including boilers, compressors, cooling towers, pumps and fans are operating near their peak capacities (i.e. best efficiency) to use the least amount of energy.

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[3] Ibid

l. Large central heating and air conditioning systems generally use 10% to 15% less energy than smaller decentralized packaged systems. However, proper controls must be installed so that the same flexibility of operation can be obtained with the central system as with individual systems. Large central systems do permit the incorporation of energy conservation devices to a greater extent than is possible with many smaller remote systems.[4]

m. Through-the-wall, window, and packaged air conditioners should be specified on a Btuh per watt basis, since there is a wide range of energy efficiencies over the entire cooling range. For example, the range is about 20% in the 8,000 Btuh models and about 50% in the 10,000 Btuh models. The minimum acceptable efficiency should be specified for other equipment such as motors, laundry equipment, air handling units, elevators, water heaters, etc.[5]

n. Reduce ventilation at extreme high and low outdoor temperatures.

o. Use the economy cycle where possible so that cool outside air is used, rather than mechanically cooling air.

p. Provide maximum selectivity in controls that will eliminate cooling and ventilation of unoccupied areas, adjust to different occupancy requirements and allow different settings for non-occupied areas.

q. Research and Development Needed:

(1) Absorption water chillers presently use

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[4] Ibid

[5] "A Study of Room Air Conditioners", N.Y. State Department of Public Service, Sept. 21, 1972.

about double the amount of energy that electric drive chillers use. Further development is indicated to reduce energy usage.

(2) The relationship of temperature and humidity on human occupants of spaces is covered broadly in the literature. More research is needed by ASHRAE.

2. Recommendations:

a. Short Range:

(1) Use outdoor design conditions based on conditions which are not exceeded more than 5% of the time for most applications.

(2) Refine design calculations (including use of computers) to avoid over-sizing equipment.

(3) Consider use of heat-of-light systems where light levels exceed 75 footcandles.

(4) Generally avoid use of high pressure, high horse-power, central fan systems.

(5) Use direct outside air supply to fume and exhaust hoods where possible.

(6) Provide hoods at equipment and exhaust heat and moisture directly to outdoors.

(7) Use area or spot cooling for special purpose areas.

(8) Study energy consumption of air-cooled versus water-cooled condensers before selection of equipment.

(9) Design equipment on a modular basis.

(10) When using large central systems, provide proper controls to maintain flexibility of operation.

(11) Specify packaged equipment on a Btuh/watt basis for more efficiency.

b. Middle Range:

(1) Develop more efficient absorption water chillers.

(2) More research by ASHRAE is needed on the relationship of temperature, humidity and air motion on human occupancy.

c. Long Range:

None.

## E. DESIGN OF VENTILATING SYSTEMS FOR ENERGY EFFICIENCY

### 1. Discussion

a. Review of existing standards of ventilation which are normally utilized in design of buildings has indicated a lack of uniformity.[1,2,3] Apparently, there are no uniform standards which are acceptable to all. The criteria established has no definite basis as to their origin or as to how each was determined. Undoubtedly, there are psychological, phsyiological, as well as other medical requirements which must be recognized and complied with in establishing ventilation standards. Since ventilation plays an important role in both the heating and cooling loads for all types of buildings, if a more specific determination of requirements can be made which will permit reduced ventilation criteria, substantial energy would be conserved. In order to implement measures to reduce the amount of ventilation air, various regulatory agencies must be willing to accept reduced standards, and agree on a single uniform code. As a first step, the minimum standard in the various conflicting codes should be accepted as satisfactory. Ultimately, the whole question of ventilation standards should be reinvestigated, with consideration given to the introduction of various filters for odor control, the problem of introducing outside air that is often of worse quality than the air within the building, the effect of

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[1] "Light, Heat, Ventilating and Noise Control", Article 12, N.Y.C. Building Code.

[2] "Minimum Ventilation Standards", N.Y.S. Building Construction Code

[3] "Systems Guide", Chapter 19; "Fundamentals Guide", Chapter 7, A.S.H.R.A.E.

infiltration, the stack effect of buildings and all other factors that influence the functioning of ventilation systems.

b. The ventilation required in most commercial and public buildings varies with the time of day and the level of building occupancy. It is only partially predictable. The rate of ventilation to satisfy odor requirements changes in a ratio of about 8 to 1 depending on whether the occupants are heavy smokers or nonsmokers. Normal occupancy of an office building may occur for only about 10 hours per day and the use of toilets and cafeterias, where high levels of exhaust are needed, occupies a correspondingly smaller fraction of the day. Toilets and kitchens, however, are often exhausted continuously, and up to six air changes of ventilation are sometimes used in hallways and public spaces regardless of occupancy. The need for zoning in ventilation and the effectiveness of zoning techniques should therefore be investigated with respect to energy conservation. Sufficient zones of temperature control should likewise be provided so that areas are neither overheated nor overcooled. HVAC systems designed for a high rate of ventilation with outdoor air during mild weather where air pollution is not an inhibiting factor, consumes appreciably less energy than systems which use treated air indiscriminately. A much lower level of outdoor air can be used during heating and cooling seasons to partially check rising energy costs required to precondition the incoming air. Furthermore, a sealed building which can make no use whatsoever of natural ventilation should be re-examined.[4]

2. Recommendations:

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[4] "$e=mc^2$, Government Report of July, 1972.

a. Short Range:

(1) Replace standard filters with carbon or charcoal units, with necessary prefilters to vitiate return air and to filter outside air.

(2) Change minimum fresh air damper openings to admit one-half the quantity presently programmed, and reevaluate its effect on the occupants and the building heating and cooling system performance, in experimental rehabilitation design program. Verify safety requirements (as in garages.)

(3) Utilize chemicals or chemically activated deodorizers in all toilet rooms and locker rooms to reduce the need for excessive ventilation.

(4) Educate operating personnel as to normal and proper operating procedures and expected performance of systems.

(5) Buildings with high ventilation requirements in certain areas, should be investigated for ways to introduce this ventilation air directly into the areas of high use.

(6) Zone ventilating systems so that spaces not requiring ventilation may be turned off easily.

(7) Utilize newly developed equipment such as filter monitoring devices to indicate system performance and to shut down ventilation systems and energize alarm when overloads occur.

(8) In building requiring extensive ventilation, isolate all such devices and/or systems requiring same and investigate the use of untreated ventilation air introduced directly to the area where it is to be utilized. Provide central controls

and/or clock-activated switches with manual override to turn off ventilating equipment (and other selected electrical equipment and lighting) that may have been inadvertently left on when the building is not in use.

b. Middle Range:

(1) The most significant changes to pursue would involve the various governmental and municipal agencies to jointly modify their existing codes and to reach agreement on ventilation standards.

c. Long Range:

None.

## F. LIGHTING ENERGY CONSERVATION IN LARGE BUILDINGS

1. Discussion:

a. In 1970, the electric utilities in this country consumed energy at the rate of 8,154,000 barrels of oil equivalent daily. By 1985, without the implementation of a major conservation program, their consumption is predicted to increase nearly threefold, to 23,580,000 barrels of oil equivalent daily. In 1970, approximately 25% of the total output of the electric utilities or 2,038,500 barrels of oil equivalent daily was consumed for lighting purposes. If the lighting load retains its relative position as a consumer of electrical energy, by 1985, it will require 5,895,000 barrels of oil equivalent daily to satisfy its demand. This is slightly less than 10% of the nation's predicted total energy consumption rate of all uses in 1985. The significance of the lighting load in the national energy picture is obvious. The lighting load therefore, should be a prime target for the energy conservation program.

b. In January, 1973, the Illuminating Engineering Society, (IES), recognizing its responsibility to the public, prepared a report[1] on the better utilization of energy used for lighting, all without reducing the quality of lighting design. Highlights of this report are as follows:

1) Design lighting for expected activity. (Light for seeing tasks, with less light in surrounding non-working areas.)

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[1] I.E.S. Report to Ad Hoc Committee on Design, January 24, 1973.

(a) The IES recommends values of illumination for visual tasks or a group of tasks in an area. In the introduction to the master table of illumination recommendations in the IES Lighting Handbook[2], the following statement is made: "While for convenience of use this table sometimes lists locations rather than tasks, the recommended footcandle values have been arrived at for specific visual tasks." Also, "Supplementary luminaires may be used in combination with general lighting to achieve these levels. The general lighting should be not less than 20 footcandles and should contribute at least one-tenth the total illumination level."

(b) Where task positions are fixed and known the lighting should be designed accordingly. However, seeing task locations are not always known so that it often becomes necessary to install task lighting at all probable task locations using a general overall lighting system.

(c) Where task lighting is provided, recommendations concerning luminance (brightness) ratios should be considered in determining levels for non-task area lighting.

(2) Design with more effective lighting fixtures, windows and skylights.

(a) Lighting fixture, window and skylight lighting effectiveness depends on how well the light provided enhances the visibility by reducing veiling reflections (reflections which will partially hide the details of a task and lower the task contrast) and disability glare (light scattered in the eyes producing a haze to look through--such as experienced with oncoming headlights at night).

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[2] "Levels of Illumination Currently Recommended", IES Lighting Handbook, 5th Edition, 1972, Fig. 9-80, pp 9-81.

(b) It has been found, for example, that polarized light and lighting from the side by luminaires of specific design can enhance task visibility by reducing **veiling reflections.** Conversely, a heavy concentration of light from overhead and forward of the task can produce a high degree of veiling reflections.

(c) Well shielded (low brightness) luminaires can eliminate disability glare, whereas bright, unshielded windows near the line of sight can produce significant disability glare.

(d) Lighting fixtures that consume equal wattage and provide equal illumination levels may not provide equal visibility of seeing tasks. Two IES reports have been published covering the evaluation of the visual effectiveness of lighting systems.[3,4] A computer program is available with others under development, to simplify the evaluation process.

(3) Use efficient light sources (higher lumen/watt output).

(a) For incandescent lamps, higher wattage lamps are more efficient.

40-watt general service produces about 11 lumens/watt input.

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[3] "A Method of Evaluating the Visual Effectiveness of Lighting Systems", RQQ Report No. 4, Illuminating Engineering, Vol. 65, August, 1970, p.504.

[4] "The Predetermination of Contrast Rendition Factors For the Calculation of Equivalent Sphere Illumination", RQQ Report No. 5, Journal of the IES, Vol. 2, January, 1973, p.149.

1000-watt general service produces about 22 lumens/watt input. Therefore, in design consider use of fewer and higher wattage lamps.

(b) For fluorescent lamps, longer length lamps are more efficient.

Two 24-inch cool white lamps produce 50 lumens/watt.

Two 48-inch cool white lamps produce 70 lumens/watt.

Two 96-inch (800 mA) cool white lamps produce 73 lumens/watt

Therefore, in design, consider use of longer length lamps.

(c) For HID lamps (high pressure sodium and metal halide) higher wattage lamps are more efficient.

400-watt phosphor coated mercury produces about 50 lumens/watt.

1000-watt phosphor coated mercury produces about 55 lumens/watt.

400-watt metal halide produces about 75 lumens/watt.

1000-watt metal halide produces about 85 lumens/watt.

400-watt high pressure sodium produces about 100 lumens/watt.

(d) For overall design, consideration should be given to the use of more efficient sources such as fluorescent and HID.

(4) Use more efficient light fixtures. More efficient luminaires produce a greater amount of light on the task with less wattage. For example, as shown in the chart below[5], in a given room, incandescent indirect light fixtures may require a load of 11 watts per square foot of floor area to produce a 50 footcandle level, but direct fluorescent troffers may only require a load of about 2.5 watts per square foot.

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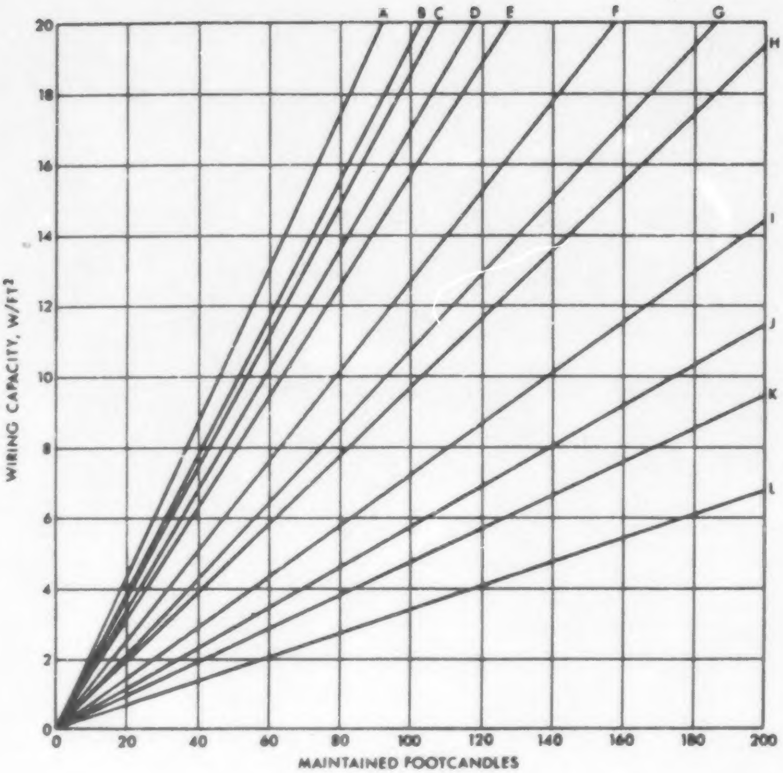
[5] IES Lighting Handbook, 5th Edition, 1972, pp 16-19.



Approximate wiring capacity to provide a given maintained level of illumination in a room of 2.5 Room Cavity Ratio by means of the following:

A—Indirect, incandescent filament (silvered bowl)
B—Direct, incandescent filament (with diffuser)
C—Direct, incandescent filament (downlight)
D—General diffuse, incandescent filament
E—Direct, incandescent filament (lens)
F—Direct, incandescent filament (industrial)
Indirect, fluorescent (cove)
G—Indirect, fluorescent (extra high output)
H—Direct, fluorescent (extra high output) (louvered)
I—Direct, fluorescent (louvered)
J—Luminous ceiling, fluorescent
K—Direct, fluorescent (lens)
Direct, HID (mercury)
L—Direct/Semi-direct, fluorescent (industrial)

Chart: Comparison of Lighting Fixtures

(5) Use thermal controlled lighting fixtures. By using fixtures with air or water heat transfer capabilities, heat from fixtures can be exhausted before entering an occupied space in warm weather or conversely, the heat can be utilized in the occupied space in cold weather. By integrating the lighting and air conditioning systems, less room heating and cooling load should be required. The IES report, "Lighting and Air Conditioning", covers the theory and application of heat transfer lighting equipment.[6]

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[6] Prepared by the Committee on Lighting and Air Conditioning of the IES, Illuminating Engineering, March, 1966. (Currently under revision.)

(6) Provide flexibility in the control of lighting. Use separate and convenient switching or dimming devices for areas that have different use patterns. Photo-electric control of the electric lighting should be considered where adequate daylighting is possible.

(7) Select lighting fixtures which can be cleaned easily and lamps with good lumen maintenance. Select lighting servicing plan to minimize light loss during operation and thus reduce the number of lighting fixtures required.

2. Recommendations:

a. Short Range:

(1) Design lighting for expected activity.

(2) Design with more effective lighting fixtures, windows and skylights.

(3) Use efficient light sources (higher lumen/watt output).

(4) Use more efficient lighting fixtures.

(5) Use thermal controlled lighting fixtures.

(6) Provide flexibility in the control lighting.

(7) Select lighting fixtures with good cleaning capability and lamps with good lumen maintenance.

b. Middle Range:

(1) Refine light level criteria to include maximum, as well as minimum standards.

(2) Develop more efficient light producing sources at all intensities.

c. Long Range:

None.

## G. EFFECT OF INSULATION ON ENERGY UTILIZATION

### 1. Discussion:

a. Walls and roofs form the envelope of buildings and protect the interior from the elements. Through the walls and roofs there is a constant transfer of energy resulting from temperature differentials between the interior of the structure and the outside ambient conditions. The rate of energy transfer through the walls and roofs is a function of the material components and the difference in temperature.

b. In all cases the measure of the wall or roof units capability to transfer energy is measured by its overall coefficient of heat transmission or "U" value.

c. Heat transfer through the exterior envelope, in addition to the energy transfer which takes place through the wall section includes the energy transfer through the windows (glass) and through infiltration or exfiltration of air through cracks or window framing.

d. To reduce the energy transfer through the envelope of the building, the "U" value of the walls, roof, and windows must be as low as can feasibly be attained. The introduction of insulating material has the effect of decreasing the "U" value of the wall or roof.

e. In the case of glass, reduction of energy transfer has been accomplished by using double or triple glazing, addition of storm windows or by the use of thermopane type glass. Since glass, even double glazing, has a higher "U" factor than most solid walls, the reduction of glass areas will generally result in lowering of overall "U" factors. This decision must be made with consideration of the trade-off factors - psychological, natural light gain, building appearance, solar heat gain in winter, cost, etc., - weighing the advantages of glazed areas that are given up for the reduced thermal transfer.

f. In general, temperature requirements in spaces are governed by codes. Minimum insulation standards or heat transfer performance standards ("U" factors) for walls and roofs are generally governed by requirements of sponsoring agencies and lending agencies. Computational methods established by the American Society of Heating, Refrigerating and Air Conditioning Engineers, (ASHRAE) are generally accepted. Determination of what materials or assemblies to use to satisfy both of these requirements is generally within the discretion of the designer.

g. Adding insulation can reduce heat transfer in walls and roofs to the point where an insulated space may require only one quarter to one half the heat input that the same space would require if it were uninsulated as indicated in the following comparisons:

| Type of Construction | "U" Value (No Insulation) | "U" Value (With Insulation) |
|---|---|---|
| Frame Construction | 0.23 | 0.07 |
| Solid Masonry (4B) | 0.29 | 0.13 |
| Solid Masonry (4D) | 0.16 | 0.13 |
| Cavity Wall (4E) | 0.21 | 0.07 |
| Masonry Roof | 0.22 | 0.11 |
| Wood Flat Roof | 0.17 | 0.04 |
| Metal Roof | 0.40 | 0.15 |

TABLE NO. 1: COMPARISON OF WALLS AND ROOFS WITH AND WITHOUT INSULATION.[1]

[1] Annex A1

The amounts of energy savings possible were checked against a hypothetical 100 foot by 200 foot masonry walled building with and without insulation and double glazing. A 49 percent saving was indicated, almost a third of which was attained through the double glazing. Since increased insulation reduces fuel consumption with the attendant reduction in health-endangering air pollutants, hydro-carbons, etc., there may well be a legal basis to set insulation (or "U" factor) requirements by code to protect public health. A goal of 50 percent reduction in heat loss by conduction is practical.

h. Three inches of insulation on a previously uninsulated building may reduce the heat loss of the insulated surfaces by 80 percent at normal design temperatures. Thicker, more massive walls and roofs not only improve the insulation value, but reduce noise transmission as well. The workmanship attained in the construction of buildings and the appropriate use of sealants, gaskets, weatherstripping and good joint design significantly affects the overall leakage and the resultant heating and cooling requirements. Cavity walls can be insulated and basement slabs should be considered for insulation. If hung ceilings are required under the roof, insulation at this point may significantly decrease thermal transmission at nominal cost.[2]

i. The actual savings of insulating a building properly to conserve energy should be calculated by a cost/benefit ratio analysis explained in Part E of this appendix.

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[2] "e=mc$^2$", Government Report, July, 1972.

j. See detailed report in Annex A1, titled - "Outside Walls, Roofs and Insulation Considerations", Nov. 8, 1972.

2. Recommendations:

a. Short Range:

(1) Require storm windows or double glazed sash, on new and existing buildings.

(2) Require insulation in walls and roofs of new buildings and where practical in existing buildings.

(3) The above insulation should be specified using insulating materials based on a goal of a 50 percent reduction in the building heat loss by conduction.

(4) That the above recommendations be on a voluntary basis for a limited period of time, say five years, then be mandatory.

(5) If economic studies are favorable, institute program of tax relief for compliance with increased insulation standards. It should be noted that the effect of tax incentives will be very minor in regard to the overall tax base and would be in force for only a relatively short period of time. Precedence currently exists for similar business tax credits under the New York State Commerce Department's Job Incentive Program.

b. Middle Range:

(1) Originate a study to develop minimum "U" values for walls, roofs, floors and windows. It is recommended that a single national agency, such as the Building Research Institute of the National Bureau of Standards undertake this effort. The State should participate in it, rather than duplicate it.

c. Long Range:

(1) Following completion, New York State should utilize the results of the above study and require the use of these minimum "U" values in new construction through legislative or other action, as required.

## H. REDUCTION OF HEAT LOSSES AND HEAT GAINS AT BUILDING ENTRANCES AND LOBBIES

### 1. Discussion

Heat losses and heat gains at building entrances are caused mainly by air infiltration. Conduction is of minor consideration. Infiltration is due to wind forces and temperature difference forces. These forces are greatly influenced by entrance traffic rate, height of building, type of doors, vestibules, air balance of supply and exhaust systems, tightness of the building envelope, orientation of the entrances, shielding from wind by adjacent structures, etc. Many of these factors are beyond the designer's control, but should be considered if feasible. Entrance infiltration may be reduced by one or a combination of the following methods:

a. Reduce the pressure differential across the entrance by sealing or tightening other parts of the building envelope. There should be no infiltration across entrances in buildings no mater how tall they are, so long as their envelopes are 100 percent tight. Apparently, most of the conventional buildings are not 100 percent tight and have a natural draft factor of 0.7. The natural draft factor is the ratio of the actual to the theoretical draft available. It was also observed that a presumably tighter-than-average building has a lower draft factor.

The building tested[1] was of metal curtain-wall construction and had windows which were tightly sealed by inflated gaskets. The lower natural draft factor was probably due to the tightly sealed windows rather than to the curtain-wall construction.[2] Unfortunately, data are not complete enough to permit quantitative correlation. Also, the criteria for tightness of the building envelope have not been established. The envelope of a building must be as tight as possible if a reduction in infiltration is to be achieved.

Against this, if the natural exfiltration of the building is considered part of its ventilation characteristics, there may be a simplification of the ventilation requirements described in section E of this appendix, without requiring an upgrading of performance of the building skin. Just as a perforated ceiling below a plenum can supply distributed air into a space, so a building skin that allows a predictable amount of air to pass through it to the exterior can be considered to contribute to the air change requirement for that building.

b. Reduce vertical airflow by sealing shafts, openings between floors and isolating and sealing elevator lobbies from entrances and other lobbies. The level of the neutral zone depends on the vertical distribution and resistances to air flow of openings through which inflow and outflow can occur. If the openings are uniformly distributed vertically, the neutral zone will be at the mid-height of the enclosure or building. If there are no space separations, or if their resistance to flow is small (the usual case),a building acts as a single chimney. If the spaces (floors) are isolated completely from one another, each has a separated chimney effect and neutral zone independent of others. In most cases there is some degree of interconnection of spaces, and the pressures within a space are affected by the action of the building as a whole. Thus, the vertical distribution of pressure differences across the walls of a building depends upon the resistance to flow of horizontal and vertical space separations as well as the vertical distribution of openings. Thus, if infiltration is to be reduced, particularly at entrances, it is important to reduce natural vertical air flow within the building to a minimum.

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[1] T. C. Min, "Winter Infiltration Through Swinging-Door Entrances in Multi-Story Buildings", ASHRAE Transactions, Vol. 64, 1958, p. 421.

[2] J. E. Emswiler and W. C. Randall, "Pressure Differences Across Windows in Relation to Wind Velocity", ASHRAE Transactions, Vol. 36, 1930, p. 83.

c. Seal entrances by using the proper type of entrance doors which allow traffic but seal flow of air. This appears to be practical and effective. Infiltration through a revolving door (except a small portion past the door seals) is almost unaffected by the height of the building, the difference in pressure between the indoors and outdoors, and fan operation. From a typical example given in the ASHRAE Guide,[3] the infiltration rate through a swinging door is about 900 cubic feet per person for a single bank entrance, and 550 cubic feet per person for a vestibule type entrance. Under same conditions, the infiltration is about 60 cubic feet per person for a manually revolving door and 32 cubic feet per person for a motor driven type. In other words, the revolving door is essentially a good air lock. The infiltration rate is primarily the amount of the displacement of air produced by the revolving of the doors.

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[3] ASHRAE Handbook of Fundamentals, Chapter 25, 1967.

Air Curtain entrances may be used at entrances with high volumes of traffic and low pressure differential between indoors and outdoors. Two important factors influencing the pressure differential which an air curtain must work against are the height of the structure and its orientation.

d. Among the energy trade-offs to be considered are amount of energy to run fans and heat or cool air currents against the amount required for the make-up air to replace air lost at entrances with other types of doors.

e. Provide the proper balance of supply and exhaust air for the building. An increase of supply over exhaust air will lower the neutral level in multi-story buildings and hence lower the pressure differential at the entrances. However, it is not economically feasible to use excess ventilation air merely for pressurizing tall buildings to eliminate infiltration problems.

f. A recent design innovation was used in a 17 story building in Utica, New York.[4] The return air pressure at each floor is regulated by means of automatic dampers at each floor, controlled by individual static pressure regulators referenced to atmospheric pressure. Each floor's return air pressure is set at 0.05" to 0.10" positive static pressure. The air conditioning system is a high velocity type, utilizing air pressure reducing units on each floor. The stack effect is completely controlled and there is no infiltration.[5]

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[4] New York State Office Building, Utica, New York.

g. The magnitude of energy saving was computed for an upstate office building,182 feet high with 700 occupants, comparing single bank swinging doors and revolving doors at entrances. The revolving doors will save 670 million Btu per year.[6]

h. The design of the entire building affects the amount of infiltration at building entrances. A tight building, carefully constructed with well planned entrances will have much lower infiltration at building entrances with minimum heat losses and heat gains at the entrances. The type of HVAC system will have a great effect of infiltration.

2. Recommendations

a. Short Range :

(1) Install revolving doors or entrance vestibules to replace single bank doors in new and existing buildings which have infiltration problems at entrances.

(2) In new and existing buildings, seal the building envelope, particularly at upper floors, so as to obtain

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[5] C. J. Busch of Barber Colman Company, "Applying Static Pressure Control in Building Areas and Duct System", Air Conditioning and Heating, April, 1964.

[6] New York State Office Building, Watertown, New York.

a tight building, if the building is designed as a sealed building.

(3) Review contract documents of buildings under construction to insure that the buildings will be of tight construction with proper entrances. Assure contract documents will provide minimum heat losses and heat gains at entrances.

(4) Review design of the HVAC systems for buildings under construction to determine if changes would be beneficial in controlling infiltration at entrances.

b. Middle Range:

(1) More coordination between architects and engineers in the design of entrances, lobbies and building tightness should be developed through an educational process.

(2) The design of HVAC systems should include control of interior static pressure throughout the structure.

c. Long Range:

None.

## I. EFFECT OF BUILDING MATERIAL SELECTION ON ENERGY UTILIZATION

### 1. Discussion

a. It is evident that the building industry, representing ten percent of the Gross National Product, is a large consumer of energy. In fact, 12 percent of industrial use of electric power is directly the result of the securing, processing and installing the materials that make up our buildings.

b. It is known that certain materials use large amounts of energy in their manufacture, and that there are other materials that perform similarly that use less energy per unit. Among those in the first category are aluminum, plastics and synthetics, principally those from a petro-chemical base. A list should be developed of interchangeable choices of materials, noting energy requirements of each per unit, for distribution to the design professions. Use of materials with lower energy requirements to produce and install should be promoted. It requires approximately six times as much electric energy to produce a ton of aluminum as compared to a ton of steel. In his analysis of a highrise building,[1] Richard G. Stein, FAIA, indicated that its skin would require 5.75 million pounds of stainless steel which takes 0.77 million KWH to produce, compared to only 4 million pounds of aluminum, but which takes 2.1 million KWH to produce.

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[1] "Spotlight On The Energy Crisis: How Architects Can Help", AIA Journal, June, 1972, pp. 18-23.

c. Building design components are often structurally excessive or unresponsive to the shapes demanded by structural considerations. Take steps - conferences, research, test procedures - independently and with other groups to improve efficiency of material usage.

d. Energy consumed in the building industry can be reduced as follows:

(1) More efficient structural analysis of materials.

(2) Elimination of redundancies.

(3) Selection of a material for assembly above another with similar performance characteristics on the basis of comparative energy intensities.

e. A building materials energy conservation research organization is required. One of its major functions would be to develop a better understanding of how energy is used through building products. Different aspects of its work should include assessment of present products and building methods, development of new concepts and materials, education in the use of these new items of information (research in control and energy delivery systems are discussed under other sections of this report).

It is recommended that a single national agency, such as Building Research Institute of the National Bureau of Standards undertake this effort. The State should participate in it, rather than duplicate it. The architectural and technical schools can develop curricula and research programs that tie into this organization.

f. A program to promote use of low energy materials is necessary. The State, with the aid of the Architectural and Engineering Professional Societies, could set up regional seminars on energy implications of design. Publications describing energy requirements of building materials selection should be written and distributed to architectural and engineering schools across the Country. The cost of preparing such a publication should be borne by the State and/or the Federal Government.

2. Recommendations:

a. Short Range:

(1) Develop a list of interchangeable choices of materials, noting energy requirements of each per unit for distribution to the design professions.

(2) Promote use of low energy requirement materials and assemblies through the architectural and engineering schools.

(3) Reduce energy consumed in the building industry by using the above information and through more efficient structural analysis of materials and elimination of redundancies.

(4) Organize a building materials energy conservation research organization to study energy use in building construction. This should be done at a national level.

b. Middle Range:

(1) Develop in more detail the listing of energy characteristics of building components. Research is underway, both in building design fields and in other fields. Coordinate and tie in these activities.

(2) Publicize the results of building materials energy conservation research organization.

c. Long Range:

None.

## J. ENERGY EFFICIENCY THROUGH HEAT RECOVERY

### 1. Discussion

a. Electric energy now is generally purchased from utility companies for lighting and power and in some cases for cooking, air conditioning, heating, ventilating and domestic hot water heating. When not by electricity, space heating is supplied by individual or central boilers or furnaces burning coal, gas or oil; cooling (air conditioning) by fossil fuel fired compressors or absorption units and cooking and domestic hot water heating by fossil fuels. Energy used in buildings is either produced in the building in the form of electricity, steam or hot water, or it is purchased from an outside utility. At present, production of energy causes some environmental pollution. Fossil fuel - gas, oil or coal - fouls the environment with the products of combustion. Nuclear power generation produces some thermal pollution of water, some small radioactive emissions and radioactive waste disposal problems. Hydraulic power plants flood large acreages above the dams. The more energy we use, the more ecological problems are compounded. Wasted energy, not only adds to the pollution problem, but accelerates depletion of our available natural resources. The U. S. Office of Science and Technology estimates that space heating, cooling, domestic hot water, illumination and power in residential and commercial buildings consume about 30 percent of the nation's total energy and contribute substantially to air pollution by emissions of sulfur dioxide ($SO_2$) and sulfur trioxide ($SO_3$); nitric oxide (NO) and nitrogen dioxide ($NO_2$); carbon monoxide (CO); unburned hydrocarbons (HC); particulate; and other fluid and solid pollutants.

b. Virtually all energy utilizations involve heat transfer systems. When there is an inefficiency it means that potential energy is lost for use, that the energy itself becomes a pollutant and that more energy is needed to remove it or offset it. Heat recovery systems and devices are used primarily to increase the efficiency of energy use and, therefore, reduce the amount of input energy required to do necessary tasks. These are sometimes lumped together as Total Energy Systems. The term is a misnomer. ASHRAE describes Total Energy as follows:

"Total energy is a term designating on-site electrical generating systems arranged for the maximum utilization of input fuel energy by salvaging by-product or waste heat from the generating process." An excellent report on total energy is available.[1]

c. There are, in addition to total energy systems, many other examples of waste heat that can be recovered with significant savings in energy use.

(1) All air conditioned systems reject heat to the outdoors. In most cases, the refrigeration equipment is water cooled with condenser water leaving the condenser at temperatures from 90 degrees F. to 130 degrees F., depending on the type of drive and design criteria. This condenser water can easily be used for preheating domestic hot water by about 30 to 40 degrees F. and can also be used for reheat in summer. If available in winter, the condenser water can be used for space heating. In many cases,

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[1] Total Energy Technical Report No. 2 - Educational Facilities' Laboratories, Inc., 477 Madison Avenue, New York, N.Y. 10022, Library of Congress Catalog No. 67-17121.

25 percent or more of the heat required for domestic hot water can be reclaimed from an air conditioning system.

(2) In buildings using steam, domestic hot water can be preheated by the steam condensate and the amount of heat recovered could be as much as 100 percent, depending on the amount and temperature of the condensate.

(3) So called Total Energy Systems reclaim some of the heat lost by fossil fuel in generating steam used for turbo generators, or utilizing hot exhaust from gas turbines for useful purposes. A Total Energy System burns its fuel first in its engines. About 30 percent of the fuel's heat energy is converted to mechanical power. Then, instead of throwing the other 70 percent into the air, this "waste heat" is reclaimed for other purposes. This is possible if the generator is rear the secondary user of heat. It is not practical to transport steam and hot water over long distances of many miles. To save a substantial part of this 70 percent of "waste heat", the engines must be reasonably adjacent to the place where heat is required. Moreover, the use for the heat must be reasonably constant so that the waste heat can be redirected as it becomes available. Load profiles should be analyzed on an hourly basis.

(4) There are cases where a utility plant, located in the heart of a big city, supplies not only electricity but also steam, hot water, and chilled water (cooled in absorption chillers) to an area of the inner city adjacent to the plant. This is Total Energy on a large scale. Most large utility company plants have no such energy-using neighbors. Their "waste heat" is rejected

into the air or into the water. The locating of large generators, particularly nuclear generators, near population concentrations has many practical difficulties that work against the Total Energy concept; however, this locating should be strongly considered. Where decentralized power plants can supply the base electrical load through waste heat recovery systems, they can supply a major portion of the energy for large buildings. Even though such generators may be less efficient than large centralized ones, they can save up to half the fossil fuel used in conventional systems. Several unrelated factors, including an increasingly greater use of air-conditioning and an increased number of large scale public-owned and owner-built housing, remove some of the major constraints which have mitigated against the broad application of Total Energy systems. There is a need for a screening manual which readily indicates the relative economic feasibility of Total Energy systems. Total Energy systems that can supply the base electric power and lighting load, can also supply all or a portion of the other energy requirements, in the form of heat for space heating, cooling and domestic hot water heating at little additional cost or expenditure of energy.

(5) Where incineration of refuse and waste takes place, either at a building complex or a central plant, the resulting heat can be recovered and reused. An example is the incinerator under construction in Nashville, Tenn., which will power a water-chilling and heating system for its downtown urban renewal area.[2]

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[2] Beverly Briley, Mayor, Nashville, Tenn., "We Will Air Condition and Heat With Garbage", The American City Magazine, November, 1972

(6) The heat of heated air that is exhausted for ventilating purposes can be recaptured by thermal wheels or other heat transfer devices.

(7) Heat given off by lights can be used for space heating or other useful purposes.

(8) The heat given off by refrigerating plants - not only air cooling plants, but refrigeration plants as well, - can be reclaimed. (One supermarket chain has announced that most of its heating can be taken care of by heat released by cooling the various freezers).

d. Three warnings are necessary in regard to energy savings through heat recovery:

(1) The recovered heat that can be used for space heating in winter, requires additional cooling in summer. For example, in general, the amount of heat necessary to cool the heat of lights in summer is greater than the energy saving in heating in winter.

(2) Even minimal use of recovered energy that would otherwise be wasted will improve overall system efficiency.

(3) For maximum benefit from heat recovery, the secondary demand must always be ready to use up the otherwise wasted energy produced by the first use.

2. Recommendations:

a. Short Range:

(1) Recognize that there is energy available within buildings which can be recovered and reused, thereby reducing primary energy requirements.

(2) Use heat recovery principles in designing heating, ventilating and air conditioning systems.

(3) Investigate the use of heat pumps in buildings.

(4) Investigate scale suitability for using total energy systems.

b. Middle Range:

(1) Develop new equipment that uses original fuel more efficiently.

(2) Develop more components with built in devices to recover heat.

(3) Conduct research to reduce the scale for efficient "total energy" production, including packaged units.

c. Long Range:

None.

## K. COST/BENEFIT RATIO ANALYSIS IN ENERGY CONSERVATION

### 1. Discussion:

a. Design decisions have in the past been heavily influenced by their impact on the construction or first cost of the building. Maintenance was considered mostly in terms of repairing and replacing building components due to the attrition of time and use. Today, because of the greater demands, reduced supplies, and increased costs of energy sources, energy use has an important effect on the overall or life cycle economics of a building. If the cost of a building is considered to be its complete cost through its whole life it becomes apparent that there are important economic gains if the building incorporates less energy requirements in its design. For convenience of computation we can use 50 years as a building's life, a span recognized by many mortgages, even though building life often exceeds 50 years. Most universities have major buildings over 50 years old. The Woolworth building is 60 years old. The Chrysler building is 43 and some buildings in Rockefeller Center are already 42 years old.

Our traditional method of economic decisions obscures this relationship. In government, and many areas of the private sector, capital and operating budgets are normally separated and financed differently. In institutional building, building costs are almost considered solely as initial, visible contract costs. In speculative building, there is a comparative market advantage to a low initial cost, disregarding lifetime cost implications.

Since overall operational cost savings will also reflect long term energy savings, the cost/benefit ratio analysis becomes an important tool in energy conservation. While it does not contain specific building design recommendations, it helps to identify and justify many of the decisions recommended in earlier sections of this report.

b. Selecting the energy supply system for a building is determined by an effort to provide the highest levels of performance throughout the structure. The search to satisfy increasing requirements has made it possible to maintain a wide range of selected interior conditions within very close tolerance. However, the attempt to improve cost/benefit ratios has not always resulted in energy conservation techniques, since the decision may be governed by a too short-term framework. When the decision is overburdened by low initial cost considerations, long-run financial economies or optimum energy use will generally be overlooked. However, the most effective use of energy resources does not invariably increase first cost. The approaches to improving energy conservation are worthy of the Architect/Engineer's most determined efforts and suitable rewards would stimulate the work.

c. Frequently the alternate ways of meeting building construction needs have comparative implications that are apparent so that the decision is relatively straight forward. Building energy supply and delivery systems, however, are more complex and will have significant differences which are not self-evident. Therefore, it is necessary that the alternates submit to rational analysis if the effects of variations are to be systematically explored. Many factors (some unique to the structure - to its occupants and use) are pertinent to the specification of the proper system. A prudent decision is dependent upon an evaluation that is made more difficult since it is impractical to reduce all differences to monetary terms.

d. Accurate determination of energy requirements or fuel consumption of the mechanical systems devices and electrical apparatus is vital if the primary objective is to optimize energy use. A high degree of accuracy can be attained by using an integrated energy analysis computer program, preferably one that permits manual verification. Failure to select the proper system can result from incomplete or misleading conclusions, and not only condemn the installation to the consequences for many years, but also reflect unfavorably on the decision maker.

e. The following are the essential steps in a comprehensive analysis prodedure to assess alternate building energy supply systems:

(1) Determine Overall Energy Requirements

(2) Make Selection of Systems and Equipment for Comparative Analysis

(3) Develop Equipment Energy Consumption

(4) Make Economic Comparisons

(5) From the Above Make Final Selection of Optimum Systems and Equipment

f. Intelligent use of a detailed analysis procedure will permit the decision maker to (1) Integrate design point calculations of peak thermal and electrical load in order to make a reliable estimate of hourly, monthly and annual energy requirements; (2) Determine the energy consumption of various types of systems which may be used to meet those energy requirements; (3) Compare the total owning and operating costs of the various systems being considered. If the input data is valid, a sound basis for comparison is established. The objectivity of procedures should be verified by separate calculations, thereby providing the user confidence to make a better energy utilization decision. Proper fees should be allocated to Architects and Engineers for this additional analysis, which will more than pay for itself in reduced energy requirements.

2. Recommendations:

a. Short Range:

(1) All State agencies involved in building should require a 50 year cost/benefit analysis study for each major project including an isolated study of energy use. Design fees should be increased to permit both the comparative studies and the cost/benefit analysis.

(2) Since this is a new area of study, the State should authorize several such studies on a time basis to establish costs for such a study.

(3) All building programs assisted by State funding (housing, schools, medical facilities, etc.) should be required to comply in a similar manner.

(4) The private sector, particularly banks and insurance companies that provide mortgages for speculative building, should be encouraged to require cost/benefit analysis before granting loans.

b. Middle Range:

(1) A central data bank should be set up to record and analyze cost/benefit performance according to building type and location. This should be part of a national agency such as the Building Research Institute.

c. Long Range:

(1) The results of the above analysis should be studied and publicized.

ANNEX A1

# AD HOC COMMITTEE ON ENERGY EFFICIENCY IN LARGE BUILDINGS

## SUB-COMMITTEE ON DESIGN

SUBJECT
OUTSIDE WALLS, ROOFS AND INSULATION CONSIDERATION

Date: November 8, 1972

Prepared by:
M. M. Duke & M. S. Burlesco
New York State Division
of Housing & Community Rerewal

## ANNEX A1

## OUTSIDE WALLS, ROOFS AND INSULATION CONSIDERATION

Walls and roofs form the envelope to give buildings identity and protect the interior from the elements. Through the walls and roofs there is a constant transfer of energy resulting from temperature differentials between the interior of the structure and the outside ambient conditions. The rate of energy transfer through the walls and roofs is a function of the material components and the difference in temperature.

In all cases the measure of the wall or roof units capability to transfer energy is measured by its overall coefficient of heat transmission or "U" value. The "U" value is usually expressed in British Thermal units (BTU) per hour per unit area (square foot) per degree fahrenheit ($^{o}F$) temperature difference between air on the inside and air on the outside of the combination of materials and also to single materials, such as window glass and includes the surface conductance on both sides.

Heat transfer through the exterior envelope, in addition to the energy transfer which takes place through the wall section, should include the energy transfer through the windows (glass). The latter should take into consideration the additional transfer due to infiltration or exfiltration of air through cracks or window framing.

It can be generally stated that in order to reduce the energy transfer through the envelope of the building, that the "U" value of the walls, roof and windows must be as low as can possibly be attained using presently known techniques of design and construction with the materials available. One widely used method for reducing the "U" value of walls and roof is to introduce insulating material which has the ultimate effect of decreasing the "U" value of the wall or roof. In the case of glass, reduction of energy transfer has been accomplished by using double glazing, addition of storm windows, use of thermopane glass or, by reduction of the glass area to the minimum area consistent with Code requirements.

## Codes and Standards

a) On the question of heating and insulation, the New York State Building Code requires compliance with applicable provisions of accepted standards. The accepted standards are identified as the "Guides and Data Books" of the American Society of Heating, Refrigerating, Ventilating, and Air Conditioning Engineers, and the National Fire Protection Association Standards.

b) The New York City Local Law No. 76 (N.Y.C. Building Code) in addition to stipulating that the calculations for heat requirement be in accordance with the ASHRAE Data books, further stipulates the minimum temperature requirements for spaces depending on the use of such space.

c) In view of the above it is evident that in any given building design situation, the designer has a liberal choice of materials and/or combination of materials which he can use to form the building envelope. His expertise in combination with that of his consultants will determine the relative amount of the energy requirements to satisfy the design conditions set up.

d) Design Standards - Many Governmental agencies, among them the Division of Housing and Community Renewal have published Design Standards, which stipulate the minimum requirement for walls, roofs and energy transfer requirement for same.

Present building design and construction practices rely on a number of accepted and basic wall and roof types. Among these are the following:

| Walls | Roofs |
|---|---|
| 1- Solid Masonry Units | 1- Concrete slab with weatherproofing |
| 2- Cavity walls | 2- Concrete slabs with applied exterior and/or interior insulation |
| 3- Curtain walls<br>a) Single skin type<br>1) Metal clad-on frame<br>2) Transite cover-on frame<br>b) Sandwich type | 3- Sandwich panel |
| 4- Glass exterior<br>Heat reflecting<br>Heat absorbing | 4- Prefabricated insulating panels |
|  | 5- Wood frame roofs with or without vented attic space |

Published data (ASHRAE Guide) of relative values of typical walls, roofs, etc., show the relative reduction of "U" value attained by the addition of insulation - for example:

|  | Construction | "U" Value (Less Insulation) | "U" Value (With Insulation) |
|---|---|---|---|
| 1. | Frame Construction | 0.23 | 0.07 |
| 2. | Solid Masonry (4B) | 0.29 | 0.13 |
| 3. | Solid Masonry (4D) | 0.16 | 0.13 |
| 4. | Cavity Wall (4E) | 0.21 | 0.07 |
| 5. | Masonry roof | 0.22 | 0.11 |
| 6. | Wood Flat roof | 0.17 | 0.04 |
| 7. | Metal Roof | 0.40 | 0.15 |

**Glass**

a) Single U = 1.13

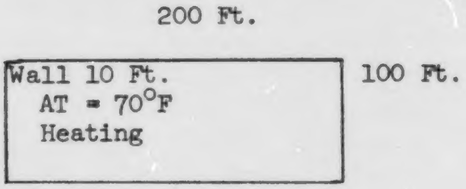
Varying air space b) Double U = 0.69 - 0.58

Varying air space c) Triple U = 0.47 - 0.36

Storm Windows U = 0.56

A comparison of heat loss of an uninsulated structure and the effect of adding insulation to typical wall sections and roof:

Solid masonry walls with masonry roof and single glass windows.



**Story Height**
**10 Ft.**

**Note** Example treats only walls, roof and glass for simplicity of comparison.

**Floor Area**
20,000 SF

Glass Area
@ 10% of Floor Area
2,000 SF

Wall Area
6,000 SF

Less Glass
2,000 SF

Net Wall Area
4,000 SF

| | | AREA | U x T = | BTU/HR. | Energy Transfer -BTU | %Savings |
|---|---|---|---|---|---|---|
| a) | Walls | 4,000 | x0.29 x 70 = | 81200 | | |
| b) | Insulated | | x0.13 x 70 = | 36400 | 44800 | 56 |
| a) | Roof | 20,000 | x0.22 x 70 = | 308000 | | |
| b) | Insulated | | x0.11 x 70 = | 154000 | 154000 | 50 |
| a) | Glass | 2,000 | x1.13 x 70 = | 158200 | | |
| b) | Double | | x0.60 x 70 = | 84000 | 74200 | 46 |
| | Total (a) uninsulated | | | 547400 | | |
| | Total (b) insulated single glass | | | 357000 | 190400 | 35 |
| | Total (c) double glass & insulation | | | 274400 | 273000 | 49 |

It can be seen from the simple comparison that the energy savings using insulated walls and roof and single glass is 35 percent over that using uninsulated walls and roof with single glass. It is noted that the addition of double glass leads to a further saving of 14 percent or a total saving of 49 percent energy transmission under design conditions. Similar savings in energy requirements can be realized for summer conditions.

Insulation of floors, building perimeter and selective treatments of ceilings and partitions can further reduce energy transfer.

Additional savings may be realized by reducing the design condition requirements based on a more detailed study of local ambient conditions and habits for both winter and summer requirements.

## Conclusions

1. Reduction of energy requirements within a structure can be reduced by:

   a) Insulating roofs and/or ceilings
   b) Insulating walls
   c) Insulating floors, perimeter and internal partitions
   d) Use of storm windows
   e) Use of double glazing or triple glazing.
   f) Use of "thermopane" type glass

2. Existing New York State Codes are voluntary.

3. Existing accepted standards are voluntary.

## Recommendations

The following recommendations are submitted for consideration:

1. A program to reduce energy use be initiated immediately.

2. Such a program should include the participation of Government, Professionals, Private industry, the Building construction industry, the public utilities and consumer representatives and agencies protecting the public interests.

3. The program might be set up to consider the question of energy use in three steps.

a) What can be done now.
b) What can be done over the next two years - intermediate.
c) What can be done for the future.

Following the above proposed type program some of the items which might be considered on the now basis would be:

1. Existing buildings be required to be equipped with storm windows, or where possible double glazed or thermopane sash.
2. Where practicable existing buildings be required to have insulation added to walls, roofs, ceilings, floors and interior partitions.
3. That the above recommendations be on a voluntary basis for a limited period of time, say five years. Inducements might include tax relief to overcome initial first costs involved to Owners.
4. An educational program be initiated and continued. The purpose of the program would be to educate the general public as to the nature of the problem, the need for cooperation and the benefits which each and all can derive from participation.

For the intermediate situation, the following are possible items for consideration:

1. The New York State Building Code be made mandatory.
2. The Code include minimum "U" values required for various construction elements - such as walls, roofs, floors - etc. - and, that it include minimum design temperatures to be maintained for various usage of space and for varying outside design conditions.
3. That Governmental agencies involved in building construction include specific design requirements for use of insulation in walls,

roofs etc., and for the use of storm windows, double glazing and/or thermopane in the construction of buildings under their programs.

For the future or long term, it is recommended that the government, industry, the profession and the public maintain constant liaison through a working organization whose purpose would be to establish a record of experience based on the first two phases of the program. With the experience at hand, it may be possible at that time to consider further reduction of "U" values for building elements and/or establish other design limitations which will lead to the conservation of energy in future buildings.

## References

1. N.Y. State Building Construction Code - July 1, 1972.
    - a) Multiple **Dwelling**
    - b) General Building Construction
    - c) One and two family dwellings

2. N.Y.C. Building Code (Local Law No. 76) December 6, 1968.

3. American Society of Heating Refrigerating and Air Conditioning Guide 1972.

4. National Association of Home Builders Research Foundation, Inc. Insulation Manual for Homes and **Apartments** - September 1971.

5. Owens-Corning Fiberglass Corporation Design of Insulated Wall in Industrial and **Commercial** Construction- Publication Number 1-PB-5341 - September 1971.

6. Department of Housing and Urban Development Federal Housing Administration "Minimum Property Standards for Multi Family Housing"

7. N.Y.S. Division of Housing & Community Renewal "Design Standards and Procedures for Limited Profit and Limited Divident Housing Projects" - Form AB-25. January 1, 1968

References

N.Y. State Building Construction Code 12/1/64
(General Building Construction)

C-504-2.10 Insulation

a) To reduce the rate of heat flow through building construction shall conform to the requirements of Sect. C-501.

b) Insulation on surfaces of heat producing equipment shall be non-combustible materials.

C-501 C General Requirements for Equipment
(855) The design and installation of equipment and systems shall conform to the requirements of Section C-107.

C-107 Acceptability
(802.2)

a) Compliance with applicable provisions of generally accepted standards, except as otherwise prescribed in this Code, shall constitute compliance with this Code.

b) Deviations from applicable provisions of generally accepted standards, when it shall have been conclusively proved that such deviations meet the performance requirements of this Code, shall constitute compliance with the Code.

N.Y. State Building Construction Code 12/1/64
(Multiple Dwelling)

B-504-2.10 - Insulation - (Same as C-504-2.10
(758.25)

B-501-C - (Same as C-501c)
(755)

B-107 - Acceptability - (Same as C-107)

One and Two Family Dwellings - 12/1/64

A-504-2.10 Insulation - (Same as C-504-2.10)

A-501-C - (Same as C-501-C)
(655)

A-107 - (Same as C-107)
(602.2)

Accepted Standards

Heating - Ventilating, Refrig. & A.C.
ASHRAE Guides and Data Books
NFPA

References

## Insulation and Heating

NYC Building Code
Local Law No. 76
Effective 12/6/68

Standards of Heating Subarticle 1204.0

§C-26-1204.1 Heating Requirements

Reference Standard Rs12-1

Outdoor Design Temp. 5°F.
Wind Velocity 15 mph

Table 12-1 Minimum Space Temp. Requirements

| | Min. Temp. of | |
|---|---|---|
| Habitable Rooms | 70 | |
| Building Equipt.& Mats. Rooms | 50 | (Temp. at 5 ft. above floor) |
| Patients rooms, bathrooms toilets & corridors in hospitals and nursing homes | 75 | |

Reference Standard 12-1 Heating -

"The heating capacity required in each room or space shall be calculated in accordance with the principles set forth in ASHRAE guide and data book - 1965-1966..."

Insulation Sound Control -

Sound Insulation of wall floor and door construction
NBS, Monograph 77, Nov. 30, 1964 - Supt. of Documents
Gov't Printing Office
Washington, D.C. 20402

Noise Reduction Control with Insulation Board ) Insulation Board
for Homes, Apartments, Motels, Offices, AIA ) Institute
File No. 39B, Third Ed. 1964 ) 111 West Washington St.
Chicago 2, Ill.

## Section 1711-7.6 Heat and Sound Insulation

(a) General

Ceiling and soffits shall be insulated in all cold areas such as unexcavated areas, crawl spaces, garages, and over-exposed lobbies and loggias, and in all hot areas such as boiler rooms and incinerator rooms, where there is a considerable difference in temperature between these areas and the living or occupied spaces above. Community, laundry rooms, boiler rooms, and similar public spaces above located adjacent to or below living spaces shall have sound-insulated ceilings and/or walls. Incinerator flues and chimneys, when adjacent to dwelling units shall be insulated.

(b) Attic Spaces and Roofs

Insulate between roof joists and attic spaces with at least 3" of inorganic insulation with vapor barrier on the warm side. The minimum "U" value for the insulated attic floor construction shall be .07. See Section 1711-8.8 for ventilation of such spaces.

Roofs of buildings of reinforced concrete or cast slab type construction shall have vapor barrier and rigid inorganic roof insulation (suitable as a base for built up roofing) of such thickness as to develop a "U" value of .15.

Section 1711-7.6 Heat and Sound Insulation (cont'd)

(c) Sound Reduction

The following floor, ceiling and partition construction shall have a Sound Transmission Class (S.T.C.) rating of not less than 45 (as per National Gypsum Company publication, "Gold Bond Sound Insulation Theory and Practice" (latest edition) or approved equal):

(1) Floor and ceiling construction between apartments.

(2) Partitions between apartments may be constructed as follows: 2-1/2" trussed steel studs, 3/8" rock lath on both sides, one side with resilient clips, 1/2" sanded gypsum plaster on both sides, or approved equal.

(3) Partitions between bathrooms or toilet compartments and living rooms in the same apartment.

(4) Walls, partitions, floor, and ceiling construction between apartments and areas with mechanical equipment, such as elevator hoistways, boiler rooms, motors, switches, incinerators, garbage collection, pump and equipment rooms.

(5) Recessed medicine cabinets back to back (adequate soundproofing is required).

(6) In addition to the above items, it is desirable that closets be used as sound barriers, where possible.

(d) Ceilings of Spaces below Living Areas

(1) Ceilings for laundries, pump rooms, fan and equipment rooms, and incinerator rooms shall be as follows:

Suspended, exposed "T" system with 3/16" x 24" x 24" or 48" perforated "Transite" asbestos cement panels and a 2" thick fiberglas overlay; or, simplex Metal Pan with 2" insulation.

Section 1711-7.6 Heat and Sound Insulation (cont'd)

(d) Ceilings of Spaces below Living Areas (cont'd)

(2) Ceiling for boiler rooms shall be either (k) or (ii) as follows:

(i) Hung ceiling, insulated with 2" magnesia block and finished with a smooth hard asbestos and Portland Cement plaster.

(ii) Hung ceiling, insulated with 4" fiberglas and steel trowel finished with Vermiculite Portland Cement plaster.

(3) Provide ventilating bricks in perimeter walls of hung ceiling spaces or other type of positive through ventilation which will prevent condensation.

(k) In cavity wall construction, install 2 oz. sheet copper, laminated with asphalt to fiber-reinforced kraft paper flashing under window sills; same to extend 1" beyond jambs. Install 1" fiberglas insulation at head and jambs of all window casings.

# ANNEX A2

# GUARANTEED EFFICIENCY METHOD
# FOR LARGE BOILERS

STATE OF NEW YORK-EXECUTIVE DEPARTMENT
OFFICE OF GENERAL SERVICES
DESIGN AND CONSTRUCTION
BUILDING NUMBER 4
STATE OFFICE BUILDING CAMPUS
ALBANY, N.Y. 12226

## STANDARD SPECIFICATION

Spec. No.

## INSTRUCTIONS FOR BIDDERS

### 1.0 General

The purpose of this section is to inform each prospective bidder as to the proper procedure to follow in the preparation of the bid and the method by which the State of New York will evaluate bids, determine the lowest responsible and reliable bidder, as will best promote the public interest, and calculate liquidated damages.

### 2.0 Definitions

The following terms, as referred to hereinafter, are defined as follows:

2.1 Bid Price is the amount in dollars of the Contractor's proposal.

2.2 Guaranteed Gross Efficiency is the predicted efficiency which the Contractor guarantees in his bid. This efficiency shall be based on 75% of maximum continuous load.

2.3 Actual Gross Efficiency is the efficiency as determined by the acceptance test specified in Section 53 as amended.

2.4 Fuel Cost is the amount in dollars of the fuel as determined by the Formula.

2.5 Lowest Responsible and Reliable Bidder is the bidder whose proposal is computed by the State as the lowest combined sum in dollars of the bid price and the fuel cost, and which will best promote the public interest.

The fuel cost as estimated by the formula is added to the bid price. The sum of these is the basis which determines the lowest combined value. The lowest combined value will be a factor in determining the "lowest responsible and reliable bidder" as defined above.

2.6 Liquidated Damages is defined, for the purpose of this specification, as the added cost of fuel due to a lower than guaranteed efficiency.

### 3.0 Submission of Bids

The proposal as submitted by the Contractor shall include the following:

3.1 Bid Price

3.2 Guaranteed Gross Efficiency

## 4.0 Evaluation of Fuel Cost

The State of New York will evaluate the fuel cost pursuant to the method of evaluation as herein specified. The fuel cost shall be determined by the following formula.

> NOTE TO SPEC. WRITER:
>
> Four formulas are included here for:
>
> (1) Steam Plant coal fired;
> (2) Steam Plant oil fired;
> (3) HTW Plant coal fired;
> (4) HTW Plant oil fired.
>
> USE ONLY ONE

### FORMULA (1)

$$\text{Fuel Cost} = \frac{a \times b \times c \times d \times e \times h \times i}{j \times k \times l} = \underset{1}{\underline{\qquad\qquad\qquad}}$$

The data used in the above formula to determine fuel cost is as follows:

(a) Capitalization period, years = 10

(b) Output of one (1) boiler at maximum continuous load lbs./hr. = ________

(c) Percent of maximum continuous load at which the boiler is to be operated, expressed as a decimal = .75

(d) Number of boilers in operation at one time = ________

(e) Total number of operating hours, per year, per boiler = ________

(f) Boiler output, enthalpy of steam, btu/lb. = ________

(g) Boiler input, enthalpy of feed water, btu/lb. = ________

(h) Difference of enthalpies (item f - item g), btu/lb. = ________

(i) Average fuel price, delivered, \$/ton = ________

(j) Lbs./ton = 2000

(k) Fuel heating value,btu/lb. HHV. = __________

(l) Guaranteed Gross Efficiency = __________

NOTE TO SPEC. WRITER:

Operating hours are determined as follows:

Annual steam output of plant in lbs.
Number of boilers in operation at one time x output of the boiler in lbs/hr.

Round out answer to nearest 1,000.

Spec. No.

IFB - 3A
FORMULA (2)

$$\text{Fuel Cost} = \frac{a \times b \times c \times d \times e \times h \times i}{j \times k} = \frac{\rule{4cm}{0.4pt}}{k}$$

The data used in the above formula to determine fuel cost is as follows:

(a) Capitalization period, years = 10

(b) Output of one (1) boiler at maximum continuous load lbs./hr = __________

(c) Percent of maximum continuous load at which the boiler is to be operated, expressed as a decimal = .75

(d) Number of boilers in operation at one time = __________

(e) Total number of operating hours, per year, per boiler = __________

(f) Boiler output, enthalpy of steam, btu/lb. = __________

(g) Boiler input, enthalpy of feedwater, btu/lb. = __________

(h) Difference of enthalpies (item f - item g), btu/lb. = __________

(i) Average fuel price, delivered, $/gal. = __________

(j) Fuel heating value, Btu/gal.,HHV = __________

(k) Guaranteed Gross Efficiency = __________

NOTE TO SPEC. WRITER:

Operating hours are determined as follows:

$$\frac{\text{Annual steam output of plant in lbs.}}{\text{No. of boilers in operation at one time x output of one boiler in lbs./hr.}}$$

Round out answer to nearest 1,000.

IFB - 33

FORMULA (3)

$$\text{Fuel Cost} = \frac{a \times b \times c \times d \times e \times f}{g \times h \times i} = \frac{\_\_\_\_\_\_\_\_}{i}$$

The data used in the above formula to determine fuel cost is as follows:

(a) Capitalization period, years = 10

(b) Output of one (1) H.T.W. generator at maximum continuous load, btu/hr. = ________

(c) Percent of maximum continuous load at which the H.T.W. generator is to be operated, expressed as a decimal = .75

(d) Number of HTW generators in operation at one time = ________

(e) Total number of operating hours per year, per HTW generator = ________

(f) Average fuel price, delivered $/ton = ________

(g) Lbs/ton = 2000

(h) Fuel heating value, btu/lb., HHV = ________

(i) Guaranteed Gross Efficiency = ________

NOTE TO SPEC. WRITER:

Operating hours are determined as follows:

$$\frac{\text{Annual HTW Output in BTU}}{\text{No. of HTW generators in operation at one time x output of one HTW generator in btu/hour.}}$$

Round out to nearest 1,000

Spec. No.

IFB - 3C

**FORMULA (4)**

$$\text{Fuel Cost} = \frac{a \times b \times c \times d \times e \times f}{g \times h} = \frac{\underline{\qquad\qquad\qquad}}{h}$$

The data used in the above formula to determine fuel cost is as follows:

(a) Capitalization period, years = 10

(b) Output of one (1) HTW generator at maximum continuous load, btu/hr. = ______________

(c) Per cent of maximum continuous load at which the HTW generator is to be operated, expressed as a decimal = ______________

(d) Number of HTW generators in operation at one time = ______________

(e) Total number of operating hours, per year, per HTW generator = ______________

(f) Average fuel price, delivered, $/gal. = ______________

(g) Fuel heating value, Btu/gal., HHV = ______________

(h) Guaranteed Gross Efficiency = ______________

NOTE TO SPEC. WRITER:

Operating hours are determined as follows:

$$\frac{\text{Annual H.T.W. Output in BTU}}{\text{No. of HTW generators in operation at one time x output of one generator in btu/hr.}}$$

Round out to nearest 1,000

NOTE: The Guaranteed Gross Efficiency in the above Formula shall be expressed as a decimal, and shall be as submitted by the Contractor in his Proposal.

The fuel heating value is based on the fuel as specified in the "Fuel Burning Equipment" Section. This is the fuel that the State expects to burn during the capitalization period.

## 5.0 Efficiency Evaluation

The State of New York reserves the right to compare the actual gross efficiency obtained against the guaranteed gross efficiency as submitted in the proposal.

## 6.0 Liquidated Damage Calculations

In the event that the acceptance test determines that the actual gross efficiency is less than the guaranteed gross efficiency, the Contractor expressly agrees to pay and the State shall be entitled to liquidated damages, and not as a penalty, the sum of money, pursuant to the calculations thereof as hereinafter described, by reason of the lower efficiency.

It is hereby fixed and agreed that the liquidated damages shall be calculated as follows:

6.1 The fuel cost shall be determined by the "Formula". The item Guaranteed Gross Efficiency shall be as submitted by the Contractor in his proposal. This fuel cost, corrected to the nearest hundred dollars, is used in the awarding of the contract.

6.2 A second calculation will be made by the State using the "Formula", except that the Efficiency will be the Actual Gross Efficiency as calculated from the acceptance test data. The Actual Gross Efficiency expressed as a decimal shall be carried out to four places.

6.3 The amount that paragraph 6.2 exceeds paragraph 6.1 shall be deducted from the contract bid price as liquidated damages.

NOTE TO SPEC. WRITER

Section 53 - Testing shall be amended as required. Refer to Standard Office Amendment to Section 53.

***********

# ANNEX A3

STATE OF NEW YORK

EXECUTIVE DEPARTMENT - OFFICE OF GENERAL SERVICES

DESIGN AND CONSTRUCTION GROUP

November 1, 1972

TO : All Division Directors, Office Chiefs, & Bureau Chiefs

FROM : Director of Design and Construction Group

SUBJECT: Establishment of the Architectural/Engineering Project Review Board

The purpose of this memorandum is to establish procedures for the broad technical review of the planning, programming, design, construction supervision and inspection of major projects (normally those projects with an estimated construction cost of $100,000 or more or projects of a sensitive or special interest nature) which are the responsibility of the Design and Construction Group in accordance with the Public Buildings Law.

The importance of the accuracy and completeness of every project cannot be overemphasized. There is, sometimes, due to the unusually short period of time available for preparation of plans, specifications, and other documents, the rationalization that these are just preliminary submissions; therefore, they can always be reviewed and changed at a subsequent time. Factually however, change is not easily accomplished by us after an estimated cost and scope have been approved by the requesting agency.

After authorization and funding of a project, the project must not exceed the scope and funding approved and must result in a complete usable facility which will satisfy the client's requirement. Therefore, it is imperative that the best possible review of the programs, plans, and specifications be made prior to submittal to the client since the final product is dictated by these documents. Review of the construction supervision and inspection phase after completion of the project will provide feedback to improve our planning, design and construction of future projects.

To ensure that projects are being thoroughly reviewed in accordance with the above by all elements of cognizant Divisions and Offices within the Design and Construction Group, an Architectural/Engineering Project Review Board is herewith established.

The Board shall be composed of the following:

| | | |
|---|---|---|
| Director D & C | - | Chairman |
| Facilities Programming Division Director | - | Member & Recorder |
| Design Division Director | - | Member |
| Architectural Bureau Chief | - | Member |
| Engineering Bureau Chief | - | Member |
| Contract Administration Division Director | - | Member |
| Construction Supervision Division Director | - | Member |
| Rehabilitation Planning Division Director | - | Member |
| Project Management Office Office Chief or Cognizant Project Manager | - | Member |

In addition, such other specialists (e.g., roofing) will be temporarily assigned as required.

The Board shall be convened for review by the Recorder at prime project milestones, such as prior to submission for approval to the client of planning/programming, schematic, preliminary and working drawing documents*, and for review of the construction phase following the final inspection of the project. Copies of material to be reviewed shall be presented to the members of the Board at least two days prior to the meeting for review. The cognizant Division representatives will briefly explain the project to the Board and the remaining members of the Board will present comments and recommendations within their areas of responsibility.

*Note: Review of one or more phases may be omitted as determined by the Director.

Harry Stevens, Jr.
Director

HS:pma

# APPENDIX B

# REPORT
# ON
# ENERGY-EFFICIENT
# CONSTRUCTION
# OF
# LARGE BUILDINGS

Submitted by:

Subcommittee on Energy-Efficient
Construction
of
Ad Hoc Committee on Energy Efficiency
in Large Buildings,
Interdepartmental Fuel and Energy
Committee of New York State

March 7, 1973

B 1

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DESIGN AND CONSTRUCTION GROUP OF THE
NEW YORK STATE OFFICE OF GENERAL SERVICES
MASTER SPECIFICATIONS FOR TEMPORARY HEAT

## I. INTRODUCTION

This Subcommittee discussed the potential role of contractors and owner-builders in the conservation of energy during the construction phase of large buildings. The types of buildings considered are large multi-dwelling residential complexes, commercial buildings, and institutional sites.

## II. SUMMARY

### A. ROLES OF CONTRACTOR AND OWNER-BUILDER

In the current role of the contractor, he normally only performs that work which is required in contractual plans and specifications produced by the architects and engineers. However, some architectural and engineering firms and their clients now consult with contractors of the various trades during the design phases of a project. Owner-builders, concerned with aesthetics, plus functional and practical considerations, have the ability as clients to impose some of these considerations on the design process. This report reflects a balance between the input of owner-builder and contractor Subcommittee members, both general and mechanical/electrical. The reader will note a reluctance on the part of this Subcommittee to intrude upon the prerogatives of the designers. However, the content of the report will reflect a willingness on the part of the contractor and owner-builder sector to lend their experience to further the prospects for energy conservation in large buildings during the design, construction, and maintenance and operational phases.

## B. TEMPORARY HEAT AND SERVICES

Temporary heat and services are used in many cases where the permanent heating and other systems may be utilized in a new building.

## C. BUILDING CODES

There are many restrictive overlapping building codes.

## D. JOINT COMMITTEES ON CONSTRUCTION PROBLEMS

Numerous joint committees are investigating means to review and resolve problems concerning labor mobility, trades jurisdiction, workmanship, and management during the construction phase.

## III. DETAILED STUDY

### A. POLICY

1. The Subcommittee members discussed at length the roles of contractors and owners-builders in energy conservation with considerable attention given not only to the construction phases, but also to the design and maintenance and operational phases as considered appropriate. This resulted from our review of the many publications, monologues, and technical papers provided the Subcommittee in advance of our meetings by the Secretariat, as well as our own personal experiences. The results of this review were that these publications did not overtly concern themselves with the potential for input of the construction sector to the solution of the energy conservation problem. Great emphasis was placed by most of these reports on the designer and owners. Our reluctance to invade the design prerogatives was of concern to the contractors present, but not to the owner-builders, who acting as clients, have the ability to strongly influence the professional design so that it will produce the best short and long-run energy conservation results commensurate with cost and standard of quality.

## B. PRACTICAL CONSIDERATIONS

### 1. Temporary Heat and Services

a. Steps should be taken to use the permanent heating, electric, water and other systems, wherever possible, in order to eliminate the provision of such temporary services. The provision of temporary heat, in particular, is costly, both in terms of manpower and energy consumption. Elimination of the restrictions, which are now placed on the operation of permanent equipment for temporary heat, would result in the earlier use of the permanent systems. Where temporary heat is required, temperatures should be specified commensurate with the actual needs at given areas of a building under construction. Certain finishing operations should be undertaken only after activation of the permanent heating system. To insure conservation of energy during the pre-occupancy phases of construction, permanent closure of structures must be accomplished at the earliest possible date, or temporary closure providing protection from the elements should be provided. If possible, temporary closures should contain materials which can be modified and incorporated in permanent closures. Heat of construction, i.e., concrete, power tools, waste steam, etc. should be retained and used to supplement temporary heat. During construction, the contractor should be required, during non-working periods, to turn off lights (except minimum lighting for security and safety), reduce building temperatures, insure shut-off of all water, etc., to conserve energy.

b. Several Subcommittee members are familiar with the work of the State's interdepartmental committee on temporary heat sponsored by the Design and Construction Group of the New York State Office of General Services in this area. The recommendations of this joint committee, which reflect inputs from architects, engineers, and contractors were reviewed; barriers to their full implementation were cited. This citation resulted in a lengthy discussion of the contents of labor agreements and the leading decision of the Supreme Court in the work preservation area. It is apparent that the leadership of some craft unions have recognized the problems created by jurisdictional strife and make-work rules by aiding in the establishment of joint labor-management committees charged with taking steps to remove the barriers cited. Several members of this Subcommittee are also members of these joint labor-management committees; they will undertake to promote the energy conservation message. The Subcommittee members emphasized the need for specification writers to use appropriate contract requirements to produce conservation of temporary heat and temporary electrical services (see Annex B-1).

### 2. Efficiency in Construction Management

The Subcommittee discussed the "new" techniques in construction management and commented on the entry of those who are unfamiliar or ill-equipped with the necessary skill, to properly manage the construction phase. It was said the degree of sophistication in construction management is improving, because of client demand for time/cost savings in an inflationary era and as a result of reduction in construction volume in this State, both in the public and private sectors. Severe competition often gives rise to cost-savings techniques and new construction management methods.

Limitations on management's rights to manage were discussed, with these limitations pictured as having significant influences on the quality and quantity of skilled manpower. Again, the problem is recognized by both the trades and construction management; State-wide committees have been organized to seek solutions to the manpower and quality control problems. The contractor members of this Subcommittee pointed to the need for proper specifications and for the appreciation of the influence of design on construction scheduling and cost. One solution to the manpower problem could come with insuring mobility of labor, but the lack of portability of benefit programs has precluded mobility. Legislation to insure such portability is regularly presented to both the Federal and State legislatures. Lack of labor mobility causes shortages of skilled labor, resulting in longer construction time, which, in turn, increases temporary services. Proper inspection, as now practiced by the Design and Construction Group of the New York State Office of General Services, to insure good workmanship, such as proper installation of insulation, sealing of building envelope cracks by caulking, etc., would result in more efficient energy use during the maintenance and operation phase.

### 3. Building Codes

The Subcommittee discussed the influence of various codes on the selection of materials which could bring about energy conservation in the manufacturing, installation, and operations phases. The New York State Building Code, now adopted by more than 600 political subdivisions, was not criticized. However, the codes of several cities were discussed and said to present severe handicaps to energy conservation. Again, the Subcommittee, believing design and code to be concomitant matters, hesitated to invade the professional's jurisdiction. Nevertheless, the Subcommittee strongly believes that a detailed study should be instituted to analyze the several codes to point up those provisions which preclude the conservation of construction and operating energies. If the need is validated by this study, a standardized common code based on minimum acceptable performance standards which would result in conservation of energy should be developed. This code should except the major cities of New York City, Buffalo, Rochester, Yonkers, and Albany, which have special high-rise requirements, particularly in the areas of fire protection and safety.

## IV. RECOMMENDATIONS

### A. SHORT RANGE RECOMMENDATIONS

#### 1. Temporary Heat and Services

a. Utilize the Design and Construction Group of the New York State Office of General Services specifications for Temporary Heat as shown in Annex B-1 as a model or standard in building construction contracts, modified as necessary for individual projects.

b. Use the permanent heating, electric, water, and other systems, wherever possible in order to eliminate the provision of temporary services.

#### 2. Efficiency in Construction Management

All designers acting as agents for both public and private clients, should consult with contractors for their inputs, during both preliminary and final design phases, for information and recommendations on construction technology and economies, with especial emphasis on ways and means for conserving energy. Such consultants could also propose construction alternatives during the planning phase and can accurately predict the effects of these alternatives on the project cost and schedule. Contractors and owner-builders should be included in the Architectural/Engineering Project Design Review Boards defined in the Design Subcommittee Report.

### 3. Instruction of Maintenance and Operation Personnel

The Subcommittee recommends that those employees of the client who will maintain and operate newly installed equipment, receive instruction in the maintenance and operation from qualified representatives of the prime contractor(s), his subcontractors, vendors, and manufacturers, with the requirement for such instruction to be set forth in the specifications. Improper operation and maintenance contributes to a great deal of waste in the utilization of energy.

## B. MIDDLE RANGE RECOMMENDATIONS

### 1. Building Codes

An in-depth study should be instituted to analyze existing building codes to determine whether they need revision in order to conserve energy. If such a need is validated, then a standardized, common code for the State of New York should be developed, based on minimum acceptable performance standards, using national consensus procedures for establishing such standards. This code should except the major cities of New York City, Buffalo, Rochester, Yonkers, and Albany which have special high-rise requirements, due to great numbers of congested high-rise buildings, especially in the areas of fire protection and safety. Specifically tailored energy conservation requirements should be developed for these cities.

### 2. Labor Benefit Portability

Sponsor or support legislation to assure portability of labor benefit programs. These would ultimately result in energy conservation by providing a better supply of skilled workmen.

## C. LONG RANGE RECOMMENDATIONS

1. All short range and intermediate range recommendations should be reevaluated, modified and updated by a separate duly authorized body to insure conservation of energy during the construction phase of large structures.

ANNEX B1

DESIGN AND CONSTRUCTION
OFFICE OF GENERAL SERVICES
STATE OF NEW YORK
MASTER SPECIFICATION

3/28/72(2)

Spec. Nos.

## SECTION 01512 - TEMPORARY HEAT

USE THIS SECTION FOR MAJOR CONSTRUCTION. FILL IN ALL BLANK SPACES.

### 1.01 GENERAL

A. Prior to the time the building, or any part of the building, is enclosed, construction heat, (as differentiated from temporary heat), shall be provided by each Contractor, as required to accomplish the following:

1. Protect material and equipment being installed as part of the Contract, from freezing.
2. Provide sufficient heat so that workmen can accomplish their labor in a satisfactory manner.
3. Provide sufficient heat to maintain construction schedules.

B. When the building, or any major part of it, is enclosed as determined by the Director's Representative, temporary heat shall be provided in accordance with this Section. The building, or any portion, shall be considered enclosed when the exterior walls, roof deck, or overhead closures are completed sufficiently to exclude the elements, except for windows, doors, ventilators and similar openings which shall be temporarily closed with suitable enclosures. In window wall type of construction, the Construction Contractor shall furnish temporary enclosures if window walls are not installed as scheduled and, in sufficient time to maintain progress of the building construction.

C. The Construction Contractor shall furnish, place and maintain _______ 8" thermometers in the building. He shall also furnish and install, where directed, _________ seven day, self-contained recording thermometers to record air temperature in the building. Thermometers shall be Bacharach 14-1010 or equivalent.

D. The Construction Contractor shall furnish a supply of charts, ink, etc., for each recording thermometer for the duration of temporary heating. The charts for the recording thermometers shall be twenty-four hour charts arranged for working temperatures from -30 degrees F. to +120 degrees F. Charts shall be delivered to the Director's Representative who will maintain operation of the recording thermometer. The recording thermometers and charts shall become the property of the State.

## 1.02 PHASE I HEAT - BUILDINGS ENCLOSED - PERMANENT HEATING SYSTEM NOT READY FOR OPERATION

A. Under Phase I, the Construction Contractor shall furnish temporary heat starting approximately ___________, or as directed by the Director's Representative. The Construction Contractor shall include in the bid price, any amount necessary to provide temporary heat for ________days. The actual number of days for Phase I temporary heat shall be as determined by the Director's Representative. In case such direction results in more or less than _________ days, then the contract price will be adjusted as provided in the General Conditions. Applicable daily charges for any price adjustment shall be the average rate paid during the period of use of Phase I temporary heat, (total cost of providing temporary heat divided by the number of days). The Construction Contractor shall furnish daily records of all temporary heat costs to the Director's Representative so that necessary price adjustments may be calculated.

B. The Construction Contractor shall provide and operate a sufficient number of heating units until the permanent heating system is available and in use. Fuel for Phase I heat shall be furnished by the Construction Contractor.

C. The heating units shall be of an approved type meeting all applicable codes and ordinances. The units shall have a combustion chamber and flue so designed that all products of combustion are vented through ducts to the outside of the building. Electric heaters shall not be used. Heat shall be maintained between 45 and 55 degrees F., unless higher temperatures are required for the installation of materials specified for the work of this Contract.

D. The Construction Contractor shall take all precautions necessary to protect all portions of the building from smoke or gas damage and to prevent hazardous conditions which may result in damages to property or injury to persons.

E. The heating units shall be moved, relocated or adjusted by the Construction Contractor as required or directed, to protect the work of all trades and Contractors.

## 1.03 PHASE II HEAT - BUILDING ENCLOSED - PERMANENT HEATING SYSTEM OPERABLE

A. The HVAC Contractor shall furnish heat under Phase II until the permanent heating system is ready for operation by State Personnel as hereinafter specified under Phase III.

B. Prior to ___________, and within 30 days after written notification by the Director's Representative to activate the permanent heating system, the HVAC Contractor shall complete all necessary work to place the heating system in satisfactory operating condition. When the permanent heating system is ready for operation, the HVAC Contractor shall use the system for temporary heat.

C. The HVAC Contractor shall include in the bid price, all costs (labor, materials and utilities except as hereinafter specified) necessary to provide temporary heat under Phase II for _________ days. It shall be the HVAC Contractor's responsibility to determine which portions of the heating, ventilating or air conditioning equipment will be needed to maintain adequate temporary heat, in accordance with this specification. The actual number of days of Phase II temporary heat shall be as directed by the Director's Representative. In case such direction results in more or less than _______ days, then the Contract price will be adjusted as provided in the General Conditions. Applicable daily charges for any price adjustment shall be the average rate paid during the period of use of Phase II temporary heat, (total cost of providing temporary heat divided by the number of days). The HVAC Contractor shall furnish daily records of all temporary heat costs to the Director's Representative so that necessary price adjustments can be calculated.

D. When directed by the Director's Representative, the HVAC Contractor shall maintain a minimum temperature of 65 degrees F. throughout the building, except that where materials require higher temperatures, the temperature shall be as required.

E. The HVAC Contractor shall thoroughly clean, test and otherwise prepare the permanent heating system for use for Phase III temporary heat. Such cleaning shall be in accordance with Section 15043 and shall fulfill Contract requirements for such cleaning.

F. Steam required for operation of the permanent heating system when used for Phase II temporary heat will be provided and paid for by the State. All other cost, except as otherwise specified, shall be borne by the HVAC Contractor.

G. The Plumbing Contractor shall cooperate with the HVAC Contractor by providing and maintaining permanent or temporary water connections as required for operation of equipment for temporary heat. The Plumbing Contractor shall include in his lump sum bid, the cost of furnishing and maintaining both permanent and temporary connections and removing temporary connections. Such costs shall include all labor charges required for maintaining the permanent or temporary water connections required for temporary heat.

H. The Electric Contractor shall cooperate with the HVAC Contractor by providing and maintaining the permanent or temporary electric wiring required for operation of the permanent heating system. The Electric Contractor shall include all costs of providing and maintaining temporary or permanent wiring and removing temporary wiring in his lump sum bid. Such costs shall include all labor required to furnish and maintain temporary and permanent wiring and electric service required to operate the heating system.

I. The HVAC Contractor shall make all necessary arrangements for and shall pay all costs in connection with providing all necessary personnel not otherwise specified for maintaining and operating the heating system used for temporary heat in the building. He shall cooperate with the Construction, Plumbing and Electric Contractors and coordinate his operations to insure that temporary heat is provided as required. The HVAC Contractor shall open and close windows as required, and also operate ventilation system, as necessary, to provide proper ventilation and drying in the building, as directed by the Director's Representative.

J. Where heating equipment, such as finned tube radiator elements, heating coils, etc., used for temporary heat may be damaged by plastering or other building operations, the HVAC Contractor shall provide suitable temporary protective covers for the heating equipment. The covers shall be kept on the equipment until all plastering and/or other work has been completed. The HVAC Contractor shall furnish and install temporary throwaway filters as required to maintain the air supply systems and equipment used for temporary heat free of dust and debris. Filters and protective covers shall be approved by the Director's Representative before installation.

K. Before the permanent heating system is turned over to the State for operation, the HVAC Contractor shall arrange for and pay all costs for cleaning all equipment of plaster and other materials accumulated on same, in a manner satisfactory to the Director's Representative. The HVAC Contractor, upon completion of temporary heating service, shall arrange for and pay for all costs to service and leave all permanent equipment, used in connection with temporary heat, in perfect operating condition.

L. The HVAC Contractor shall furnish and install permanent filters as required, prior to the completion date.

M. All temporary equipment provided by the HVAC Contractor, for temporary heating services, and which are not part of the permanent system shall be removed by the HVAC Contractor when no longer required.

## 1.04 RESPONSIBILITY

A. The Construction Contractor shall be responsible for all damage due to frost and freezing during the period when Phase I temporary heat is required by his Contract. He shall also be responsible for any damage due to improper equipment or the use of his equipment, such as stains, smudges, soot or fire and shall make good any damages in a manner satisfactory to the Director's Representative. The HVAC Contractor shall be responsible for all damage due to frost or freezing during the period when Phase II temporary heat is required by his Contract.

B. Damage to fire risers, roof leaders, etc., installed in enclosed portions of the building which, in the opinion of the Director's Representative, are needed for building protection, shall become the responsibility of the Contractor furnishing heat and the installing contractor shall be reimbursed for such freezing damage which is caused by lack of heat.

C. Any Contractor who does not progress his work so that phased temporary heat can be provided as and when specified shall be held responsible to pay all costs of continuing temporary heat under the phase in operation at the time of delay until he has completed his work so that temporary heat can be provided under the required phase. If more than one Contractor is responsible for delay, such cost shall be pro-rated as determined by the Director's Representative.

## 1.05 PHASE III - OPERATION BY STATE PERSONNEL

A. When in the opinion of the Director's Representative, the permanent heating system is completed, the Director's Representative will arrange for such operation in accordance with the requirements of the General Conditions concerning State occupation and operation. At this time, all Contractors will be relieved of responsibility for temporary heat.

Spec. Nos.

## SECTION 01513 - TEMPORARY HEAT

USE THIS SECTION ON MINOR NEW CONSTRUCTION. FILL IN ALL BLANK SPACES.

### 1.01 GENERAL

A. Prior to the time the building, or any part of the building, is enclosed, construction heat, (as differentiated from temporary heat), shall be provided by each contractor, as required to accomplish the following:

1. Protect material and equipment being installed as part of the contract, from freezing.
2. Provide sufficient heat so that the mechanics can accomplish their labor in a satisfactory manner.
3. Provide sufficient heat to maintain construction schedules.

B. When the building, or any major part of it, is enclosed as determined by the Director's Representative, the Construction Contractor shall provide temporary heat during the heating seasons in accordance with this Section. The building, or any portion, shall be considered enclosed when the exterior walls, roof deck, or overhead closures are completed sufficiently to exclude the elements, except for windows, doors, ventilators and similar openings which shall be temporarily closed with suitable enclosures. In window wall type of construction, the Construction Contractor shall furnish temporary enclosures if window walls are not installed as scheduled.

C. The Construction Contractor shall furnish, place and maintain ______ 8" thermometers in the building.

D. The Construction Contractor shall also furnish and install, where directed, ______ seven day, self contained recording thermometers to record air temperature in the building. Thermometers shall be Bacharach 14-1010 or equivalent.

E. The Construction Contractor shall furnish a supply of charts, ink, etc., for each recording thermometer for the duration of temporary heating. The charts for the recording thermometers shall be twenty-four hour charts arranged for working temperatures from -30 degrees F. to +120 degrees F. Charts shall be delivered to the Director's Representative who will maintain operation of the recording thermometer. The recording thermometers and charts shall become the property of the State.

## 1.02 DESCRIPTION

A. The Construction Contractor shall furnish and operate a sufficient number of heating units and provide and pay for the fuel required for their use. The installation of heating units shall be as directed.

B. The heating units shall be of an approved type meeting all applicable codes and ordinances. The units shall have a combustion chamber and flue so designed that all products of combustion are vented through ducts to the outside of the building. Electric heaters shall not be used. Heat shall be maintained between 45 and 55 degrees F., unless higher temperatures are required.

C. The Construction Contractor shall take all precautions necessary to protect all portions of the building from smoke or gas damage and to prevent hazardous conditions which may result in damages to property or injury to persons.

D. The heating units shall be moved, relocated or adjusted by the Construction Contractor as required to protect the work of all trades and contractors.

## 1.03 RESPONSIBILITY

A. The Construction Contractor shall be solely responsible for all damage due to frost and freezing resulting from his failure to provide adequate temporary heat. He shall also be solely responsible for any damages due to improper equipment or the use of his equipment, such as stains, smudges, soot or fire and shall make good any damages in a manner satisfactory to the Director.

B. Damage to fire risers, roof leaders, etc., installed in enclosed portions of the building which, in the opinion of the Director's Representative, are needed for building protection, shall become the responsibility of the Construction Contractor and the installing contractor shall be reimbursed for such freezing damage which is caused by lack of heat.

C. It shall be the responsibility of the Construction Contractor to provide and maintain acceptable approved heat until the completion date of all contracts as indicated in the Proposal. If completion is delayed beyond the scheduled completion date, the Construction Contractor shall maintain the required heat at his own expense until his contract work is satisfactorily completed.

## SECTION 01514 - TEMPORARY HEAT

USE THIS SECTION FOR REHABILITATION ONLY. FILL IN ALL BLANK SPACES.

### 1.01 GENERAL

A. Temporary heat shall be provided by the Construction Contractor during the heating season in accordance with this Section.

B. The Construction Contractor shall furnish, place and maintain ______ 8" thermometers in the building.

C. The Construction Contractor shall furnish and install, where directed, ______ seven day, self-contained recording thermometers to record air temperature in the building. Thermometers shall be Bacharach 14-1010 or equivalent.

D. The Construction Contractor shall furnish a supply of charts, ink, etc., for each recording thermometer for the duration of temporary heating. The charts for the recording thermometers shall be twenty-four hour charts arranged for working temperatures from -30 degrees F. to +120 degrees F. Charts shall be delivered to the Director's Representative who will maintain operation of the recording thermometer. The recording thermometers and charts shall become the property of the State.

### 1.02 DESCRIPTION

A. The Construction Contractor shall furnish and operate a sufficient number of heating units and provide and pay for the fuel required for their use. The installation of heating units shall be as directed.

B. The heating units shall be of an approved type meeting all applicable codes and ordinances. The units shall have a combustion chamber and flue so designed that all products of combustion are vented thru ducts to the outside of the building. Electric heaters shall not be used. Heat shall be maintained between 45 and 55 degrees F., unless higher temperatures are required.

C. The Construction Contractor shall take all precautions necessary to protect all portions of the building from smoke or gas damage and to prevent hazardous conditions which may result in damages to property or injury to persons.

D. The heating units shall be moved, relocated or adjusted by the Construction Contractor as required to protect the work of all trades and contractors.

## 1.03 RESPONSIBILITY

A. The Construction Contractor shall be solely responsible for all damage due to frost and freezing resulting from his failure to provide adequate temporary heat. He shall also be solely responsible for any damages due to improper equipment or the use of his equipment, such as stains, smudges, soot or fire and shall make good any damages in a manner satisfactory to the Director.

B. Damage to existing fire risers, roof leaders, etc., which are needed for building protection, shall become the responsibility of the Construction Contractor.

C. It shall be the responsibility of the Construction Contractor to provide and maintain acceptable approved heat until the completion date of all contracts as indicated in the Proposal. If completion is delayed beyond scheduled completion date, the Construction Contractor shall maintain the required heat at his own expense until his contract work is satisfactorily completed.

# APPENDIX C

# REPORT
# ON
# ENERGY-EFFICIENT
# MAINTENANCE AND OPERATION
# OF
# LARGE BUILDINGS

Submitted by:

Subcommittee on Energy-Efficient
Maintenance and Operation
of
Ad Hoc Committee on Energy Efficiency
in Large Buildings,
Interdepartmental Fuel and Energy
Committee of New York State

March 7, 1973

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# I. INTRODUCTION

## A. BACKGROUND

The nation faces ever increasing demands for fuel and energy. The demand for energy at the point of consumption has exceeded or is rapidly exceeding the supply, depending on geographical area. New York State is among the states most seriously affected by this energy crisis. The shortages in energy supplied are or will be the result of shortages in acceptable fuel sources or inadequate electrical generation capabilities.[1]

The environmental pollution crisis has overshadowed and increased the energy crisis. Some government agencies have not appropriately reacted to the seriousness of the energy problem. Many government leaders consider the pollution problem more pressing than the energy crisis.

Existing pollution abatement regulations, shortage of fossil fuels, power plant location problems and the inefficient use of existing energy have resulted in the current crisis.

An Interdepartmental Fuel and Energy Committee was appointed by Governor Nelson A. Rockefeller to explore the potential for energy conservation in the State of New York. This Interdepartmental Committee, realizing the urgency and need for energy conservation in facilities, established an Ad Hoc Committee for Energy-Efficiency in Large Buildings, which includes representatives from both the private and state government sectors. This Ad Hoc Committee was subdivided into three Subcommittees covering Design, Construction, and Maintenance and Operation. This report is on Energy-Efficiency in Maintenance and Operation of large buildings in the commercial sector, institutional buildings, and large multi-dwelling residential complexes.

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[1] Joseph Swidler, The Role of Energy Conservation in Regulation. A talk by Joseph Swidler, Chairman, New York State Public Service Commission, to The Albany Chapter Producers Council, Inc. on November 13, 1972.

## B. SCOPE

This report addresses itself to the review and evaluation of existing and future operations and the presentation of recommendations for improving energy usage. Recommendations were written to preclude substantial changes to the current standard of living and environmental comfort of the general population, and without creating an impediment to the orderly growth of business within New York State. It is recognized that these energy demands will continue to grow and that these progressive demands cannot be completely prohibited. However, they must be controlled within the capabilities of current and anticipated energy sources.

Industrial processing plants and off-site utility generating plants were not considered by the Subcommittee due to its time constraints; however, they are users of great quantities of energy and thus should be the subject of future studies.

## C. GOALS

The goals of the Subcommittee and the purposes of this report are to develop guidelines which recommend techniques, programs and criteria for energy efficient use of buildings, their environmental systems and their energy consumption. The implementation of these recommendations, including educating the public, executive orders affecting State buildings, and legislated statutes and codes, will be the responsibility of the Interdepartmental Fuel and Energy Committee as noted in its Action Plan.[2]

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[2] Interdepartmental Fuel & Energy Committee's Action Plan for Energy Conservation & Efficiency in Large Buildings, Aug. 9, 1972, p. 3.

## II. SUMMARY

The major areas for energy-efficient maintenance and operation of large buildings resulting in energy conservation include the following items:

### A. ENERGY EFFICIENT OPERATIONS

1. Establish maximum winter temperatures and mininum summer temperatures as a function of interior space environmental requirements.

2. Establish hours of operation of building heating, air conditioning, ventilating, lighting and other systems. Reduce operating time of HVAC equipment by utilizing thermal energy stored in the building and piping.

3. Reduce electrical peak demands by priority selectors, demand limiters and load shedding. Improve building power factor where feasible,

4. Increase combustion and heating system efficiencies by repair or replacement of insulation, replacement or repair of defective controls and equipment, installation of required weather stripping, sealing of exterior cracks, improving controls and zoning, etc.

5. Reduce unnecessary lighting.

6. Investigate use of tax incentives to induce owners to conserve energy.

## B. ESTABLISH OR INCREASE EFFECTIVENESS OF MAINTENANCE PROGRAMS

Improved maintenance and operation procedures will reduce energy consumption at least 15 per cent.

## C. INSTRUCT OR MOTIVATE OWNERS OF LARGE BUILDINGS TO INITIATE UTILITIES BETTERMENT PROGRAMS

## D. ESTABLISH OCCUPANCY STANDARDS WHICH WILL RESULT IN CONSERVATION OF ENERGY

## E. FUEL AND ENERGY UTILIZATION

The artificial environment of existing buildings, including lighting and HVAC systems, represents a substantial percentage of the total energy consumption. Increased control of these sophisticated systems and continual analysis of building demands and its minimum requirements will contribute to optimum use of fuels and energy. They are normally identified by operations personnel and brought to the attention of the owner for any required modifications.

Reduction of piping, valves and equipment leakage, and repair or replacement of insulation, will aid in conservation of fuel and energy, as well as reduce owner operating cost.

## III. DETAILED STUDY

Efficiencies can only be obtained by improved facility management, with direction and backing by their top management, aimed at and geared to efficient use of energy and conservation of energy.

The following maintenance and operation procedures and techniques are discussed and analyzed with resultant specific recommendations:

### A. ENERGY EFFICIENT OPERATIONS

#### 1. Establish Minimum Levels of Environmental Comfort

Existing methods of operation may provide excessive heating, cooling and ventilation. All heating, ventilating and air conditioning controls should maintain the recommended temperatures as indicated in the table below:

Table on Guide to Recommended Temperatures

| Room Use | Winter | Summer |
|---|---|---|
| Occupied Space*<br>e.g. office, educational | 74° to 77° F.[1] | 77° to 79° F.[1] |
| Normally Unoccupied Space | 65° F. or lower* | None |
| Storage Rooms, Equipment Rooms, etc. | 65° F. or lower* | Minimum Required |
| Vacant Spaces (normally not used) | 50° F. or lower* | None |

* Based on consensus of members of this Subcommittee.

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[1] Carrier Air Cond. Co., Handbook of Air Conditioning System Design, 1965 Ed., Table 4, p. 1-20.

For occupied space in preceding table, building operators should strive to maintain minimum winter and maximum summer space temperature, consistent with occupant comfort. Continuous operations such as residential areas of hospitals and correctional facilities should maintain these environmental conditions at all times.

Investigate the feasibility of raising the interior space humidity conditions, in order to maintain interior space at lower temperatures in the winter and higher temperatures in the summer for the same equivalent comfort conditions, without causing condensations on the windows. Higher relative humidities in the winter will reduce ventilation needs and lower the dry bulb temperature for the same degree of comfort - with a net gain in fuel reduction.[2]

### 2. Establish Hours of Operation

a. The nature of a particular occupancy will determine the minimum hours of operation for the energy consuming systems. Environmental systems should be manually or automatically programmed to start up and/or shut down an hour or so before and after occupancy. Study the optimum length of time and the amount of energy per facility to bring its low night temperatures up to operating temperatures. Lighting should be substantially reduced or eliminated in unoccupied space. The existing occupancy schedule should be reviewed to determine where reduction or rescheduling of working hours, as feasible, would contribute to the energy conservation program.

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[2] Fred S. Dubin, Energy Conservation Through Building Design and A Wise Use of Electricity, Paper prepared for presentation at the Annual Conference of the American Public Power Association in San Francisco, California on June 26, 1972, p. 5.

b. Control of ventilation systems should be adjusted to eliminate or reduce fresh air requirements during non-occupancy or low occupancy periods, during both the heating and cooling seasons (exclusive of ventilation of critical areas, i.e. volatile chemical storage areas).

### 3. Reduce Electrical Peak Demands

a. The reduction of peak demands would ease the power generation problem. The timing and magnitude of such demands must be determined for each site. Where recording demand meters are available, the utility should provide the energy user with copies of the time-demand charts. The availability of time-demand records enables an energy user to anticipate and reduce peak demands. These peak demands should be established and analyzed for causes. The facility manager should then minimize those peaks by adjustment of operating schedules. Methods of reducing peak demand include the utilization of priority selectors, demand limiters and load shedding.

b. If not installed on existing systems, the installation of a demand controller, modification and installation of controls and control circuits for heat pumps and water heaters for a typical high-rise apartment would pay for their cost in less than two years by reducing the annual electric bill.[3] Similar economical analogies can be made for institutional or commercial buildings. Demand charges constitute one-third to one-half of a typical electric bill for a large commercial or industrial installation. These needs should be identified by operating personnel and reported to building owners.

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[3] "Brownouts & Building Operation", Syska & Hennessey, Inc. Technical Letter, Vol. 21, No. 1, May 1971.

## 4. Power Factor Correction

a. The correction or improving of the power factor increases the electrical efficiency of a power distribution system in addition to permitting more effective use of the utility's capacity.

b. Low power factor increases the power company's cost of supplying actual power because more current must be transmitted. This cost is billed directly to the consumer through reactive charges. Low power factor also causes overloaded generator, transformer and distribution lines with resulting voltage drops that are greater than they should be. Low power factor also reduces the load handling capacities of the plant's electrical system. An economical and practical solution to the low power factor problem is the installation of capacitor banks if not currently installed. These needs should be identified by operating personnel and reported to building owner. To further promote this practice, the existing public utility rate charges for reactive demand should be substantially increased to provide an incentive for a good power factor and a penalty for poor power factor.

## 5. Shut-Down/Start-Up Procedures

a. Shut-down and start-up procedures should be established to guarantee the efficient use of energy consuming systems. The established procedures should reflect a cyclic starting schedule for equipment with large starting currents and the minimum time required to bring the system on the line with minimum load peaking. These procedures should vary with the conditions that exist. Daily, weekly, monthly and/or semi-annual shut-downs may have different start-up procedures based on the systems concerned and the environmental climate needed at the time.

b. The fans and pumps use approximately 40 percent of the energy demanded by an air-conditioning system. Many systems are designed to be shut down overnight and during weekends and holidays, but are not operated in this fashion; consequently an opportunity for energy saving is lost. Cooling and heating of totally unoccupied space such as storerooms and vacated areas should also be reduced or eliminated.[4]

6. Check and Improvement of Equipment Efficiencies

a. The periodic inspection of all equipment, and subsequent maintenance and alterations to improve efficiencies, should be one of the initial steps to improving energy efficiencies.

b. A system schematic should be developed with all appropriate design parameters listed. These design parameters should be evaluated and revised to reflect current environment requirements as opposed to original design requirements. The maintenance of the design or currently desired requirements should be the initial step toward effective operation. These parameters should then be compared with actual operating conditions to determine the efficiency of the system's equipment and to highlight trouble areas. Once inefficient and trouble areas are located, immediate attempts should be launched to correct or improve the deficiency.

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[4] NBS/GSA July 1972 Report, $e=mc^2$, May 23-24 Roundtable on Energy Conservation in Public Buildings, p. 56.

c. The particular action taken to improve equipment efficiency is based on the consideration of the equipment involved, the cost of corrective action and the parameters affected.

### 7. Operating Techniques Utilizing Night Setback and Thermal Lag

a. Night Setback of Building Temperatures

(1) Night setback of building temperatures should be accomplished by automatic means. Optimum night setback of building temperatures should be determined by the building operator in regard to the required morning operating time to bring the building back to daytime desired occupancy building temperature - too long a time is inefficient.

(2) Fuel savings can amount to three-quarters of one percent for each degree Fahrenheit that the thermostat is set back in an apartment or home. For example, by reducing the thermostat 4 degrees, i.e. from 70 to 66 degrees F., a savings of $1.80 on a $60 per month heating bill can be achieved.[5] Similar analogies can be made for other areas, offices, etc.

b. Utilization of Building Thermal Lag

(1) By experimentation, the building operator should determine allowable reduction time of heating and cooling equipment, by taking advantage of thermal lag, both within the buildings, as well as external piping.

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[5] U.S. Office of Consumer Affairs, 7 Ways to Reduce Fuel Consumption in Household Heating Through Energy Conservation, Pub. No. 5-BL-5253.

(2) On days expected to be very hot, the building can be cooled below normal during the night and early morning hours, allowing the inside air temperature to rise during the afternoon. The cooling equipment can be shut off altogether somewhat prior to closing time. This practice reduces the overall load on the cooling equipment, as well as the amount of power consumed during the peak load period.

### 8. Installation or Utilization of Existing Economy Cycle Equipment

a. Utilization

(1) The economy cycle, if installed in the energy consumption and distribution system of a facility, should be properly utilized.

(2) The equipment in the economy cycle should be included in the overall system analysis, which will be used to determine equipment and system operational efficiencies.

(3) Ensure that when the internal temperatures in the building are being adjusted before the start of the normal business day, that the ventilation system is closed until the building is brought to the desired temperature.

(4) The most important concept to emphasize to operating personnel is that heating and cooling equipment must be used sparingly. During approximately 500 of the 3,100 hours per year that a typical office building is occupied, outside air could be introduced into the ventilating system with neither pre-heating nor pre-cooling. This, in itself, would result in about a 20 percent

reduction in energy required for air handling.[6]

### b. Installation of New Equipment

Often, the building operator originally identifies the need for an economic survey of the possible use of new economy cycle equipment for their existing large building. Then the owner should hire a design engineer to make a survey, evaluation and any required recommendations. This study should include an analysis of first cost of new economy cycle equipment versus its reduced operating cost to determine if it is feasible, and the time required to write off the initial investment of the owner. (See following paragraph No. 12 on Tax Incentives.)

## 9. Combustion and Heating System Efficiencies

### a. Goals

The immediate objective of those in charge of the operation and maintenance should be to operate buildings at the highest level of efficiency. The longer term objectives should be physical improvements which will raise the existing efficiency of operation to insure that original design efficiencies are maintained, and to incorporate new technology. However, many buildings may not be capable of great improvement in efficiency without moderate to large capital expenditures. Most existing buildings can experience some improvement in energy usage. Some examples are shown in the following portion of this section.

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[6] Op. Cit. NBS/GSA, July 1972 Report, $e = mc^2$, p. 56.

b. Investigations

(1) Determine the maximum practical level of efficiency permitted by the design of the building. This can be done in a number of ways:

(a) Review of the original design, if available, from the architect or the designer who estimated the annual fuel consumption.

(b) Recalculation, using modern techniques of estimating design heat losses and heat gains. Assistance of the original heating design engineer may be required.

(c) Review with the heating equipment manufacturer(s), their expected efficiencies as presently installed and their proper operating procedures.

(2) After this determination of the ideal situation, the actual operating record of the building should be compared with the data. If energy consumption is significantly above what is indicated from the design data or estimate, this would be a clear indication that improvement should be made by bringing this to the attention of the building owner and/or manager, who, in turn, should hire a heating design engineer to make a study.

(3) There are two basic heating efficiencies in any building, the combustion efficiency of the heating device and the distribution efficiency of the heating system. The easiest efficiency to check and to maintain is the combustion efficiency. Boiler combustion efficiency tests should be taken often, i.e. daily, weekly or monthly for power plants, or annually for small boilers with less than 1 million Btuh input.

(a) A steady downward trend in efficiency is an indication that other maintenance work should be performed.

(b) The heating system efficiency may be more difficult to improve, but an effort should be made in this direction.

(c) System efficiency is usually determined by the original design. On a short term low capital expenditure plan, system efficiency can be improved by insulation of distribution lines wherever practical, replacement of defective radiation devices and valves; and the balancing of steam, hot water and air systems to prevent overheating lower floors in order to heat upper floors. Weather stripping of doors and windows, and sealing exterior openings and cracks will reduce infiltration losses.

### 10. Lighting and Energy Conservation

#### a. The Significance of Lighting in the Energy Conservation Program:[7]

By 1985, without the implementation of a major conservation program, the electric utilities daily consumption of oil equivalent will increase from over 8 million barrels in 1970 to about 24 million barrels. Of the 1970 total, approximately 25 percent or 2 million barrels per day was consumed for lighting purposes alone. By 1985, it will require slightly less than 6 million barrels of oil equivalent per day.

#### b. An Energy Conservation Program for Lighting in Existing Buildings:

Lighting in buildings constructed prior to 1973 will comprise approximately 43 percent of the 1985 lighting load. The opportunity for energy savings in this category requires "imagineering" as well as practicality. Savings can be accomplished by utilizing educational programs for occupants, building maintenance and operational personnel and building owners similar to Con Edison's "Save-A-Watt" program, or by distributing to these people Illuminating Engineering Society's (IES) recommendations on operating and maintaining lighting for optimum use of energy. Procedures and practices for energy-efficient lighting for existing buildings, include the following:

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[7] Subcommittee Report on Energy-Efficient Design of Large Buildings, Appendix A.

(1) Use efficient incandescent lamps for lamp replacement.

(2) Turn off lights when not needed.

(a) When a working or living space is empty, secured and not used for display or observation, there is no need for lighting. In this case, it is always more economical to turn off incandescent lighting and, where off-time is more than a few minutes, fluorescent and high-intensity discharge lighting should be turned off.

(b) Minor renovations can be undertaken that increase switching choices so that lights may be turned off by smaller areas, or permit installation of new efficient fixtures to perform tasks at lower energy input than existing fixtures.

(c) Corridor and room lighting levels can be reduced to the maximum extent consistent with actual requirements by removing bulbs in selected lights, or substituting lower wattage bulbs, by additional electrical switching, etc. (Caution:

In fluorescent fixtures, damage can result from disconnecting one lamp in a two-lamp fixture.)

(d) Lights should be turned off wherever practical after working hours, rather than leaving them on continuously throughout the building until the end of cleaning operations per section of the building.

Nighttime - Reduce lighting at night, except that needed for security.

Daytime - Turn off lights or reduce lighting, especially for non-occupied, partial-occupied, or non-critical areas.

(e) Higher wattage General Service lamps are more efficient than the lower wattage lamps. Therefore, using fewer higher wattage lamps may save power. For example, one 100-watt lamp produces more light than two 60-watt lamps (1740 lumens vs 2 x 860 = 1720 lumens).

(f) For the same wattage, General Service lamps (750 to 1000 hours life) are more efficient than Extended Service lamps (2500 hours life). For example, a 100-watt General Service lamp produces 17.4 lumens/watt input while a 100-watt Extended Service lamp produces 14.8 lumens/watt input. For equal lighting results in this case, 17.5% more lamps and power are required when using the Extended Service lamps. Extended Service lamps should be used where maintenance labor costs are high or where lamps are in inaccessible locations.

(3) Control window brightness

The requirements for good lighting can be achieved by skillful application of daylighting techniques. Encourage building maintenance and operation personnel and occupants to use the following techniques:

(a) Redirect available light for better interior distribution and utilization, such as venetian blinds.

(b) Limit the brightness of fenestration to within comfortable limits by utilizing existing shades, screens and blinds.

(4) Utilize daylighting as practicable

The levels of illumination recommended by the IES are not based on electric lighting exclusively. IES publishes a booklet entitled Recommended Practice of Daylighting[8] and includes daylighting design data in its IES Lighting Handbook as a guide to the utilization of daylight. It is pointed out, however, that because of the wide variation in daylight (from several thousand footcandles down to zero), an adequate electric lighting system should be provided.

(5) Keep lighting equipment clean and in good working condition.

Studies have shown that good lighting maintenance procedures provide better utilization of the lighting system. For example, a study of one fluorescent lighting system, where different maintenance procedures were used, showed that:

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[8] "Recommended Practice of Daylighting," Illuminating Engineering, August, 1962.

(a) When luminaires were cleaned and relamped once every three years, the illumination dropped to 60% of the initial after three years.

(b) When luminaires were cleaned every one and a half years and relamped every three years, the illumination dropped to 68% of the initial after three years.

(c) When luminaires were cleaned once a year and one third of the lamps replaced once a year, the illumination dropped to 78% of the initial after three years and to 75% even after 12 years.

Therefore, if better maintenance procedures are followed, it may be possible to reduce the total number of lamps in a given system as long as adequate illumination is still maintained.

In designing new lighting systems, more attention should be given to maintenance procedures and the consumer (tenant or owner) should be aware of the maintenance procedures considered in the design.

(6) Post instructions covering operation and maintenance.

For building owners' and tenants' information, as consumers, all illuminated spaces should have a set of instructions covering the operation and maintenance of the lighting (electric or daylight), both for maximum utilization of power and minimum consumption for economic considerations.

(7) If painting is required, use light finishes on ceilings, walls, floor and furnishings.

Light finishes can increase the utilization of light. For one room painting test by the Illuminating Engineering Society, by repainting ceiling, walls and floor and refinishing furniture, the average illumination level was increased from less than 10 footcandles to over 40 footcandles.[9]

(8) In selecting light finishes, reflectances should be in the following range:[10]

The upper limits have been selected to avoid excessively bright surfaces which can be uncomfortable or reduce visibility by producing disability glare.

11. Water Conservation

a. In multi-dwelling residential complexes, the old style standard toilet tank holds up to 5 to 8 gallons of water, which is far more than needed for flushing. However, newer models are being built with a smaller cubic capacity of about 3½ gallons. But, in the average existing town, enough water is being wasted to float a battleship. Installing an ordinary brick in the tank of each toilet will displace over a quart of water; an enormous saving per municipality can be effected. This energy conservation program was adopted in Cherry Hill, New Jersey for 17,000 homes, resulting in a savings of about 34 million gallons of drinkable water a year.[11]

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[9] IES Lighting Handbook, 5th Edition, 1972, p. 5-17.

[10] Ibid, p. 11-5.

[11] Tilly Spetgang, "A Brick in Your Tank," Parade, February 11, 1973.

Similar applications will apply for multi-dwelling residential complexes.

b. Similarly, water conservation programs can be adopted for commercial buildings and institutional buildings by adjusted flushometer valves to an experimented accepted lower rate.

c. All leaky pipes, faucets, valves, traps, controls and equipment should be repaired.

d. Makeup water for all cooling towers should be checked to insure that only the minimum amount is furnished.

e. Reduce use of water for building aesthetics, such as fountains.

## 12. Tax Incentives

a. Tax incentives should be investigated to induce owners to invest in modifications, rehabilitation and major repairs of their buildings to conserve energy. These modifications include installation of additional insulation, storm windows, insulating glass, vestibule enclosures, additional HVAC controls, additional lighting switching, weather stripping, etc. Rehabilitation and major repairs includes replacement and patching of insulation, correcting all leakage, caulking of building envelope openings, upgrading of combustion equipment and controls, etc.

b. Significant changes in tax structuring and energy prices must be examined, including the complex questions of feasibility and acceptance by the consumer. Means of carrying out conservation measures fall into three general categories: standards and regulation, tax incentives (credits and penalties) and educational campaigns. The use of standards and regulations offers precise control, but they may be difficult to compose and monitor. Their existence may also inhibit innovative solutions.[12]

c. The total cost of tax incentives for modifications of a large building to conserve energy is very small in comparison to the total tax levied on the large building, i.e., the reduction of total tax received by governments is very nominal and for a short time period; however, these modifications would result in a reduced maintenance and operation cost of the building over a long time period. Precedent currently exists for similar business tax credit under New York State Commerce Department's Job Incentive Program.

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[12] "Studies Indicate Energy Uses, Suggest Ways to Reduce Consumption", Actual Specifying Engineer, Nov. 1972, p. 27.

## B. ALTERATIONS TO EXISTING BUILDINGS

### 1. General

General opportunities for improving the energy consumption performance of existing buildings are much more limited than for oncoming new buildings. However, the percentage of buildings specifically designed to conserve energy will remain small for years to come due to the hundreds of thousands of existing buildings.

### 2. Identification of Alterations

The building operator and/or manager is responsible to make the original identification of maintenance and operational problems, which may require rehabilitation, alterations, replacements, improvements or repairs to the building, its components or systems. This information should then be brought to the attention of the owner, who, in turn, will probably require the services of a design engineer to make a field survey, evaluation, recommendations, estimates and any required contract documents. Some examples are as follows:

a. Thermal improvement of an existing building is normally a very attractive investment, since reduced energy costs will usually pay for the adjustment in a reasonably short period. Consideration should be given to additional insulation in ceilings, walls and crawl space for large multi-dwelling residential complexes, which have easy access to attic and crawl spaces.

b. Consideration should be given to the installation of storm windows and doors, and insulating glass, especially for the larger buildings.

c. Consideration should also be given to the possibility of installing more sophisticated controls so that the flexibility of heating and cooling areas in the building will be increased.

(1) The installation of a number of indoor/outdoor anticipating thermostats, each controlling a different zone in the building.

(2) Increasing the flexibility of existing heating or cooling distribution systems by increasing the number of zoned internal areas.

d. At the time of the heating plant replacement, a re-evaluation of the design heat loss and hot water requirements should be made. New equipment should closely match the re-evaluated criteria and not be sized to duplicate the old equipment, which may have become missized. Multiple heating plant design should be considered. Use design considerations from design of new building criteria. Consideration should be given on the use of separate small boilers for the summer domestic hot water requirement only.

e. Building operator should have input to above investigations.

3. Demolition

The choice to renovate or demolish and rebuild an old building should always include an assessment of the energy savings or waste involved. Building operator should have input to any decision to renovate, or demolish and rebuild an old building.

## C. PREVENTIVE MAINTENANCE PROGRAMS

### 1. Introduction

a. Maintenance of equipment and insulation is so germane to energy efficiency that it justifies special attention. Energy is often wasted through improper utilization and care of equipment. Regular maintenance checks are imperative. For existing buildings, new or updated, clearly defined maintenance procedure manuals should be provided by consultants specializing in this field. Adjacent to each major item of equipment, mount piping and/or electric schematic diagrams with instructions encased in plastic. In addition, a master series of all schematic diagrams and instructions, encased in plastic, mounted on a large clipboard or in a binder, should be made available for the chief building operator. Building operators should undergo a thorough training program to emphasize energy conservation in utilization as well as maintenance. Detailed written preventive maintenance programs should be developed and stringently followed for all building components, equipment and systems.

b. There are some readily available preventive maintenance programs and energy conservation programs that can be adapted to a large building or building complex. For many large sites these programs can be integrated into one overall program.

c. Examples of an energy conservation program are described in the Department of the Navy's brochures, NAVDOCKS P-75 and MO-303, on Utilities Conservation Program Survey

Manual and Use of Utility Targets. The General Service Administration also has available literature on energy conservation guidelines for public buildings, which can be adapted for State, municipalities and private office buildings.

### 2. Preventive Maintenance to Increase Efficiencies

It is conservative to say 90 out of every 100 buildings are operating at less than 90 percent of their potential due to poor maintenance.[1] Improved maintenance practices can reduce energy consumption of buildings by more than 15 percent without increasing maintenance labor costs.[2] An evaluation of all equipment installed in the environmental and energy distribution systems should be made to determine the amount of preventive maintenance required to insure energy efficiency. Preventive maintenance which improves energy efficiencies should be performed on all major equipment. A review of these procedures and an update of the preventive maintenance program should be accomplished at a periodic interval. This review should be performed often enough in order to incorporate new practices and add additional equipment, so that the program stays current. A main objective is to incorporate future conservation of energy practices as they become technically available. The proper planning and analysis for the program integration and operation is a key factor to the ultimate success of any new program.

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[1] Fred S. Dubin, The New Architecture and Engineering, Paper prepared for presentation at The Workshop on Total Energy Conservation in Public Buildings in Albany, N.Y. on Jan. 12, 1972, p. 15.

[2] Op Cit., Dubin, Energy Conservation, p. 15.

### 3. Preventive Maintenance to Reduce Energy Waste

a. A regular periodic investigation of the entire facility should be made in areas where energy is being wasted or ineffectively consumed, i.e., air infiltration and water leaks (including steam, condensate, domestic hot water, cold water, hot water, and/or chilled water).

b. Preventive maintenance on valves, pumps, etc. should be performed to minimize leakage. Correct blowdown quantities should be established.

c. Filter cleaning and proper replacement should be performed to insure optimum heat transfer.

d. Keep all domestic hot water heating coils free from scale deposits that will reduce the heat transfer through the coils.

e. Some important maintenance suggestions to maximize energy efficiency of HVAC systems and minimize thermal losses are as follows:[3]

(1) Regularly inspect and repair wall and ceiling insulation, caulking and storm windows.

(2) Verify that pipe insulation is provided and maintained in good repair on all steam or hot water lines passing through air-conditioned spaces, and on all chilled water lines and ducts containing cold air which pass through nonair-conditioned space.

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[3] Op. Cit. NBS/GSA, July 1972 Report, $e = mc^2$, p. 59.

(3) Keep condensers on air-conditioned units, refrigerators, freezers, and drinking water fountains clean and free of any foreign matter that might interfere with flow of air or otherwise reduce heat transfer.

(4) Check for leaky hot water faucets and radiators.

(5) Check refrigerator and freezer doors for defective gaskets.

(6) Establish a regular schedule for checking, in particular, fans, pumps, compressors and other rotating equipment to ensure that they are in good repair.

## 4. Maintenance of Building Controls

### a. Heating, Ventilating & Air Conditioning Controls

The proper functioning of HVAC controls is one of the most basic requirements for energy efficiency and system safety. Preventive maintenance of controls, including the repair, recalibration and adjustment of inoperative or ineffective controls, should be performed for optimum system efficiency in order to maintain building control systems; it will be necessary to hire and/or properly train "in-plant" personnel, or enter into control service contracts.

### b. Heating Plant Controls

These types of controls include boiler sequencing controls and other types of automatic or semi-automatic controls which will modulate and attempt to match the heating system output to the building load. Stack analysis controls which will continuously monitor stack temperature and carbon dioxide or oxygen as a determinant of efficiency may be warranted when the heating systems have inputs of over 100,000,000 Btuh.

### 5. Maintenance of Building Lighting

A planned maintenance program to emphasize energy conservation would also call for more frequent bulb replacement. Present maintenance plans often prescribe initial over-illumination, since it is assumed that one or more bulbs in an area will fail prior to replacement. Regular and more frequent cleaning of lamps, lighting fixtures, reflectors and shades can maximize lighting efficiency.

### 6. Presentation of Operation Information

Each building should have a space in the utility area with a desk, bookshelf and plan rack for operating personnel. All operation and manufacturers data should be bound in permanent binders, tabbed with index tabs for different systems and items of equipment. Master maintenance and operation manuals should be stored here. There should be lubrication schedules and filter replacement schedules filed here. There should be complete lists of sub-contractors who supplied equipment and sources for parts replacements. There should be a list of emergency telephone numbers of manufacturers of critical equipment, such as oil burners, boilers, air conditioning machines, etc. Complete sets of as-built plans, on cloth or other indestructible material, should be permanently attached to plan rack holders. A file with a complete set of shop drawings should be kept by the maintenance staff. Maintenance and operating instructions with schematic systems diagrams, encased in plastic, should be permanently mounted near the equipment they relate to, in an accessible area for easy reference.

## D. COST/BENEFIT ANALYSIS

### 1. General

Each building owner should analyze each existing building or building complex in regard to the cost for inspection, repair, rehabilitation, alteration, improvement, maintenance and preventive maintenance for both short and middle-range savings. The relatively small expenditures on these requirements will prevent the need for major rehabilitation work in only a few years. All initial expenditures required for annual need identification and budget allocation, in both the maintenance and rehabilitation areas, should be reviewed by proper management. Their review should be not only on original costs, but also on the potential savings in the short range, which will be accomplished by meeting these requirements, rather than on a future crisis basis.

### 2. State of New York Studies

a. Office of General Services, Design and Construction Group, Division of Rehabilitation Planning, has the responsibility to conduct studies for economical methods for providing services in the maintenance and rehabilitation fields.

b. In 1970 they conducted an inter-agency task force on the recalibration and repair of combustion controls and instrumentation of 75 large State power plants. The study recommended that a team of four control specialists survey these power plants on a programmed annual geographical basis in regard to required repair, maintenance, recalibration and replacement of controls. Based on 1971 prices, the total potential fuel cost savings would be at least $670,000 at the end of the first year by implementing these task force recommendations. After five years these savings will increase to 1.2 million dollars per year on a continuing basis with the ultimate reduction in fuel costs of residual oils and coal being 3 million dollars per year on a continual basis. The cost/benefit ratio is about 1 to 7 at the end of the first year, 1 to 10 at the end of the fifth year, progressing to an annual return of 1 to 25 after the tenth year and each year thereafter, based on 1971 prices. Proper continuing periodic inspection and allocation of funds for needed work not only saves the owner money in the short, middle and long ranges, but also conserves fuels.

c. In 1970, the Division of Rehabilitation Planning's second task force on the most economical and efficient means of roof inspection resulted in the recommendation to train 150 State site maintenance employees on a one time, geographical basis in order to make their proper bi-annual roof inspections, inventories and minor repairs. The value of this training is illustrated by the fact that a single roof replacement may cost $20,000 to $30,000 depending on its size, while if a roof defect is noted early enough through inspection, a minor repair of about $1,500 may prevent the necessity for this replacement work. The State has over 10,000 buildings, so the cost/benefit ratio can be extremely low to the State. By reducing roof replacements through proper early identification and repair will save raw materials and the energy needed to produce new roof installations.

d. Private engineering consultant firms hired by the State, the Parson-Jurden Corporation and the Pope, Evans and Robbins Consulting Engineers conducted maintenance management surveys for the Department of Mental Hygiene and the State University of New York, respectively. Early implementation of their recommendations on both maintenance and preventive maintenance programs at each facility would result in an overall savings and proper allocation of manpower, as well as extended life of equipment and building systems. In turn, this results in better utilization of energy and reduces energy waste. Similar approaches to the large buildings of the private sector of the State would vastly increase the savings in energy consumption.

### 3. Review Existing Maintenance & Operation Costs

A complete review and analysis of existing maintenance and operation expenditures is a useful technique in determining trouble areas. However, there must be appropriate and functional maintenance management systems available to provide both adequate and accurate information concerning these expenditures.

An accurate historical file on all the systems and accessory equipment should be available including the cost of the fuel and utilities, preventive maintenance program, repair and/or replacement expenditures, trouble calls, logs, etc. All increases in operating costs should be appropriately explained, such as rate increases, excessive overtime use of the building or its major components, additional installed equipment, new operating techniques, weather conditions, etc. All unexplained energy consumption or increases should be analyzed for inefficient or wasteful use.

4. Anticipate Growth

All increases in energy consumption and costs should be anticipated for current and future budgeting. All increased consumption projections should be matched with anticipated energy savings wherever possible. The scope of all alterations to the existing facilities (including economic and feasibility study of prime movers and sub-systems) should be reviewed to prevent excessive energy consumption.

## E. ESTABLISH OCCUPANCY STANDARDS

The instruction of the occupants of a facility in the proper conservation of energy is of major concern to the successful implementation of an efficient energy conservation program.

The use of policy statements, recommendations memoranda, educational programs, executive orders, etc. should be used to advise the occupants of the various ways to reduce energy use. These instructions should include, but not be limited, to the following:

1. Turn off all unnecessary lighting. Reduce high level corridor lighting and turn off lights in perimeter areas near windows when daylight is sufficient. Turn off lights in all vacant areas. Curtail all accent or decorative lighting.

2. Shut down all electrical equipment when not in use (i.e. coffee urns).

3. Lights used for advertising purposes should be limited to business establishments that are open for service. Billboard lighting should be restricted to hours of maximum traffic at night.

4. Curtail use of elevators during low passenger flow patterns.

5. Windows should not be opened (except for emergencies) during operation of air conditioning or heating systems.

6. Thermostat settings should be reviewed to see if their daytime settings can be lowered or raised in the winter or summer, respectively. Use night and weekend temperature setback where feasible.

7. Curtail use of local air conditioning units.

8. All furnishings, drapes, etc. should be removed from in front of HVAC units.

## IV. RECOMMENDATIONS

This Subcommittee makes the following recommendations:

### A. SHORT RANGE

#### 1. Guidelines For All State and Non-State Buildings

a. Initiate a public communication program relating to the energy crisis and the need to conserve energy. This program should use the various media and include specific energy conserving instructions. The cost of the communication program should be the responsibility of government, on Federal, State and municipal levels.

b. The following energy-efficient maintenance and operations features of large buildings should be recommended as guidelines for State, municipal and private buildings:

(1) Reduce corridor, room and outdoor lighting to the maximum extent consistent with operational requirements, safety and security. The above-mentioned reductions in light level can be accomplished by turning off selected lights, substituting incandescent lamps of lower wattage, reducing total illumination per area to the minimum requirement of the Illuminating Engineering Society, and installation of additional localized switching. Use efficient incandescent lamps for replacement. Control window brightness during daylight hours to redirect and utilize the available light, limit glare and limit heat producing radiation to reduce air conditioning load.

(2) Shut down air conditioning equipment and reduce heating levels to the maximum extent possible on weekends and holidays in buildings unoccupied during those periods.

(3) Reduce heated and cooled air supply to unoccupied space such as storerooms and unoccupied areas. (See table of Paragraph III.A.1. of this report.) Establish minimum winter and maximum summer operating temperatures as a function of room use.

(4) Reduce amounts of outside ventilation air used in central heating, ventilation and air conditioning systems to meet the minimum ventilation requirements of the latest issue of ASHRAE Guide, or, if feasible, reduce outside ventilation air even further to minimum allowed by applicable code. Insure proper use of economy cycle where equipment is available. Verify that the distribution of supply air through the building is balanced.

(5) Give consideration, on days expected to be hot, to cooling the building below normal during the night and early morning hours and allowing the inside air temperature to rise during the afternoon. This action would reduce the cooling requirement and the amount of power consumed by air conditioning equipment during the peak load period.

(6) Determine whether adjustments in the system now installed will permit the varying of inside temperature and relative humidity so that equivalent comfort can be maintained for the occupants at lower temperatures in the winter and higher temperatures in the summer.

(7) Keep filter systems clean to insure adequate circulation within the building and minimize fan horsepower.

(8) Reschedule the operation of all large motors wherever possible to times other than power peak demand periods. Examples: Large electric motor-driven water pumps often may be operated at night to replenish storage tanks. Cold storage plant compressors may be shut down over peak demand periods, provided action is taken to assure doors to refrigerated space are kept closed.

(9) Inspect and repair where necessary, the wall and ceiling insulation, caulking, weather stripping and storm windows of all buildings.

(10) Verify that pipe insulation is provided on all steam or hot water lines passing through air conditioned spaces, and on all chilled water lines and ducts containing cold air which pass through non-air conditioned space.

(11) Clean periodically, as required, all lamps, lighting fixtures, reflectors, and shades to assure maximum lighting efficiency.

(12) A water conservation program should be initiated to reduce the water consumption of toilet facilities to minimum acceptable levels. Correct all water leakage. Insure minimum allowable cooling tower blowdown. Reduce application of water for aesthetic uses.

(13) Post instructions covering operation and maintenance procedures for occupants, building operators and building managers.

c. Individual employees and tenants of large buildings of the State, municipalities and private sector should be encouraged to:

(1) Turn off window air-conditioning units shortly before the end of the business day.

(2) Close the damper which admits outside air to minimum position while the equipment is used for cooling, when individual window air conditioning units are provided.

(3) Report leaky water faucets, radiators, piping, valves, etc. immediately.

(4) Draw or partially close blinds, shades, and draperies on the sunny side of the building.

(5) Keep windows or outside doors closed during heating and cooling seasons.

(6) Utilize the minimum artificial lighting during daylight hours in rooms provided with adequate windows or skylight illumination. (Discontinue if excessive glare or heat gain results.)

(7) Keep other unnecessary lights turned off, such as those in storerooms, closets, or other spaces not being occupied.

(8) Shut off lights when leaving the office or other work areas.

(9) Turn off electric fans, coffee makers and other appliances when not required, particularly during peak load periods.

(10) Use stairs when possible, instead of elevators, particularly at quitting time or for business between floors.

(11) Practice energy conservation at home.

Note: Copies of the above recommendations should be printed by the State and distributed to all State workers and managers, and adequate copies furnished to all proper authorized management of municipalities and the private sector.

2. Implementation

Designate an appropriate State body to continually oversee the implementation and updating of the energy conservation program. This body shall have the authority and required funding necessary to obtain private consultants to assist them.

3. Evaluation

Continually evaluate the results of the short-range recommendations, validate and update these recommendations as necessary.

4. Regulatory Codes

Establish national regulatory codes to restrict or penalize the inefficient or wasteful energy consumer. A central national agency should be empowered to serve as coordinator and distributor of allocated funds for implementation of Federal code requirements. Note: The U. S. report on "Patterns of Energy Consumption in the United States" points out that many measures it proposes require further investigation, legislation and review for economic impact. Consequently, any implementation of any

N.Y.S. Committee's recommendations on energy conservation should be closely coordinated with those of the Federal Government.

## B. MIDDLE RANGE

### 1. Mandatory Requirement For Only State Buildings

Require each State facility to implement the recommendations on energy conservation of this section. This implementation shall include the planning of capital improvements and manpower necessary to realize these energy savings, plus any required executive orders. (The State should print and distribute copies of this report to each State facility.)

The proposed recommendations for each State facility are as follows:

a. All items of previous section on short-range recommendations which have not been implemented.

b. Assign a top management official and staff personnel at each major State facility to monitor and supervise the energy conservation effort to insure that prescribed guidelines are being carried out.

c. Publicize the use of strict conservation practices through announcements at staff meetings, notices posted on bulletin boards, and newsletters. Where reductions in equipment use are made in public buildings or facilities, post notices describing why this is necessary.

d. Implement occupancy standards and minimum environmental limits developed in the Detailed Study of this report, by occupants, and facility managers and operators.

e. Consider advancing the working hours in areas where employees occupy air conditioned buildings, so that quitting time occurs prior to the period of peakload demand at which time air conditioning would be shut down. Consideration should also be given to shutting down of air conditioning equipment prior to quitting time. Staggering office building hours and use of air conditioning this way will help reduce the peakload demand.

f. Reschedule work requiring large amounts of power to avoid peakload period, as feasible. If possible, postpone such work during periods of extended warm weather.

2. Distribution of this Report

Print and distribute copies of this report to the operators of all large non-state buildings and request their voluntary implementation of its energy conservation guidelines and subsequent management techniques.

3. Prototype Implementation

On an existing large building implement the recommendations of this report as a prototype to quantify conservation of energy principles and any possible resulting reduced maintenance and operation costs.

4. Cost/Benefit Analysis

Each building owner should have a cost/benefit analysis to document allocation of funds for their maintenance and rehabilitation needs.

5. Environmental Pollution vs Energy Crisis

Initiate a complete study to review and evaluate the existing environmental pollution codes versus the Energy/Fuel Crisis. Revise the criteria in N.Y.S. pollution codes, accordingly, to reflect the requirements of existing energy crisis, if allowable by U. S. Government standards. Bring this problem to duly authorized Federal authorities if changes required cannot be accomplished.

### 6. Industrial Sector Study

Encourage private sector representatives of some major industrial processing plants and off-site utility generating plants to conduct studies to recommend energy-efficient maintenance and operation of the industrial sector.

## C. LONG RANGE

1. Review and revise public utilities rate structures to encourage energy conservation.

2. Establish tax incentives aimed at energy conservation.

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## APPENDIX D

## AD HOC COMMITTEE ON ENERGY EFFICIENCY IN LARGE BUILDINGS

### COMMITTEE MEMBERS

| Representing | Name and Firm |
|---|---|
| Interdepartmental Fuel and Energy Committee<br>Overall Ad Hoc Committee Direction | General A. C. O'Hara<br>Commissioner, Office of General Services (OGS)<br>State of New York - Executive Department |
| Office of General Services<br>Design and Construction Group<br>Ad Hoc Committee Chairman | Harry Stevens, Jr.<br>Director, Design and Construction Group<br>Office of General Services<br>State of New York - Executive Department |
| Public Service Commission<br>Ad Hoc Committee Co-Chairman | Parker D. Mathusa<br>Chief, Engineering Studies and Statistical Reports Section<br>Power Division<br>Public Service Commission<br>State of New York |

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| Building Research Institute (BRAB) | Benjamin H. Evans*<br>Executive Secretary |
| American Gas Association | Thomas J. Loberg<br>Manager, Energy Systems |
| Electric Energy Association | - Paul C. Greiner<br>Vice President |
|  | - K. G. Adgate<br>Industrial Processes and Lighting Applications, Manager |

* Was unable to attend meetings.

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|  | - Robert J. Nespeco<br>Staff Engineer |
| New York City Department of Buildings | - Joseph Stein<br>Commissioner |
|  | - Dr. Charles W. Lawrence |
| Division of Housing and Community Renewal<br>State of New York - Executive Department | - Milton M. Duke<br>Assistant Commissioner |
|  | - Mario S. Burlesco |
| New York State Urban Development Corporation | - Carl K. Panero<br>Deputy Director, Design and Engineering |
|  | - Harvey K. Walcoff |
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# APPENDIX E

## DEFINITIONS

1. Demand Limiters are devices which control and limit the demand on a particular circuit or item of equipment. When the demand reaches a pre-set limit, that circuit is automatically disconnected. Demand limiters are usually installed with automatic priority selectors.

2. Economy Cycle is a design method aimed at reducing operating cost of a HVAC system. It is basically the design, control and actuation of valves, dampers, etc. to use and blend outside and return air to obtain the minimum in preheating and precooling costs.

3. Energy as used in this report includes the natural sources of energy such as coal, gas, oil, other fuels, and water. Energy shall be further used to include its distribution and form such as electricity, steam, hot water, chilled water, etc.

4. Groups of Large Buildings as used in this report are limited to three groups. These are commercial, institutional, and multi-dwelling.

   a. Commercial Buildings shall include office buildings, mercantile offices, shopping centers, and general assembly structures such as field houses, theaters, etc.

b. Institutional Buildings shall include hospitals, nursing homes, universities and schools, correctional facilities, etc.

c. Multi-dwelling Residential Complexes shall include hotels, apartment houses, dormitories, housing developments with central utilities, etc.

5. Power Factor is the ratio of actual power used (kilowatts) to the power which is apparently being drawn from the utility (kilovolt-ampere).

6. Priority Selectors are manual or automatic selection of electric circuits to be energized and de-energized, based on the priority or importance of the equipment on that circuit.

7. Reactive Charge is the utility's charge to the customer for the reactive power. Reactive power is when the apparent power (kilovolt-amperes) exceeds the actual power (kilowatts). Reactive power occurs when the lagging power factor is less than 1.0.

## ABBREVIATIONS

1. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers
2. HVAC - Heating, Ventilating, and Air Conditioning
3. IES - Illuminating Engineering Society
4. M & O - Maintenance and Operations
5. PM - Preventive Maintenance
6. N.Y.S. - New York State

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